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Review article

How well do people living with neurodegenerative diseases manage their finances? A meta-analysis and systematic review on the capacity to make financial decisions in people living with neurodegenerative diseases

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ABSTRACT

Self and proxy reported questionnaires indicate that people living with a neurodegenerative disease (NDD) have more difficulties with financial decision-making (FDM) than healthy controls. Self-reports, however, rely on adequate insight into everyday functioning and might, therefore, be less reliable. The present study provides a comprehensive overview and meta-analysis of studies evaluating FDM in people living with an NDD. For this, the reliability of performance-based tests to consistently identify FDM difficulties in people living with an NDD compared to healthy controls is evaluated. Furthermore, the associations between FDM and disease severity, performances on standard measures of cognition and demographics are evaluated. All 47 included articles, consistently reported lower performances on performance-based FDM tests of people living with an NDD (including Alzheimer's disease, mild cognitive impairment, frontotemporal dementia, Parkinson's disease, multiple sclerosis or Huntington's disease) compared to healthy controls. The majority of studies, however, focused on Alzheimer's disease and mild cognitive impairment (k = 38). FDM performance appears to be related to cognitive decline, specifically in working memory, processing speed and numeracy.

1. Introduction

The ability to make financial decisions in ones' own self-interest is essential for an independent life. Difficulties with financial decision-making (FDM) may lead to financial insecurity, poverty or financial abuse (Lai and Karlawish, 2007; Manthorpe et al., 2012; Okonkwo et al., 2008) and the (early) detection of deficits in FDM is, therefore, of utmost importance. The legislation regarding the mental capacity to make financial decisions differs between countries. In England and Wales, for example, but also in the Netherlands, the law presumes that a person has the capacity to make financial decisions unless this person is deemed to lack this capacity. This means that people with unrecognized or undetected deficits in the capacity to make financial decision can continue to make such decisions even though they may need support. The capacity, or competence, to make financial decisions is an umbrella term that includes not only practical skills and abilities (e.g., counting coins), but also the ability to judge and make (complex) decisions (American Bar Association Commision on Law and Aging and American Psychological Association [American Bar Association Commision on Law and Aging and American Psychological Association [ABA/APA], 2008). FDM encompasses various cognitive functions (Glimcher and Glimcher, 2014) and appears to rely on the integrity of the frontal cortex (Kennerley and Walton, 2011). Cognitive functions found to be related to decision-making in general include working memory, executive

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functioning and numeracy (Chen et al., 2014; Martin et al., 2012; Reyna et al., 2009).

Neurodegenerative diseases (NDDs; e.g., Alzheimer's disease (AD), Parkinson's disease (PD) or Huntington's disease (HD)) are characterized by a progressive decline of cognition and neuropsychiatric disturbances (American Psychiatric Association, 2013; Hardiman and Doherty, 2016), which makes people living with an NDD particularly vulnerable for difficulties with FDM. Indeed, research using self or proxy reported questionnaires showed that people living with an NDD have more difficulties in 'financial skills' or 'financial management' than healthy controls (Pérès et al., 2008; Wadley et al., 2003; Wicklund et al., 2007). Even years prior to the diagnosis of AD (Pérès et al., 2008) and HD (Beglinger et al., 2010), people living with these conditions report more difficulties with FDM compared to healthy controls.

Self-report questionnaires, however, rely strongly on an adequate insight into everyday functioning and might, therefore, be less reliable (Wadley et al., 2003). Furthermore, people living with an NDD with comorbid depression tend to report significantly more problems with cognitive functioning in everyday life than people living with an NDD who are not depressed, even when no effects of depression on the performances on performance-based neuropsychological tests are found (Koerts et al., 2012; Middleton et al., 2006). Finally, previous research has shown that questionnaires often do not give a good reflection of what is measured with performance-based standardized neuropsychological tests (Fuermaier et al., 2014; Koerts et al., 2012; Toplak et al., 2013). In contrast to self or proxy reported questionnaires, performance-based tests directly examine an individual's performance on tasks or during activities using standardized scoring procedures (Engel et al., 2016; Moore et al., 2007). Performance-based tests are frequently administered in an experimental or clinical environment and provide a practical and adequate alternative for real life observations (Moore et al., 2007). Therefore, in order to ascertain in a reliable and valid manner to what extent people living with an NDD can make financial decisions, performance-based FDM tests need to be used.

The aim of the present study is to provide a comprehensive overview and meta-analysis of studies evaluating FDM in people living with an NDD. For this, an evaluation of the reliability of performance-based tests to consistently identify FDM difficulties in people living with an NDD compared to healthy controls will be conducted. If possible, the performances on tests of FDM between groups with different NDDs will also be compared. Furthermore, the influence of disease severity and disease progression on FDM will be explored as well as the associations between FDM and performances on standard measures of cognition and demographic variables (i.e., age, sex and education).

NDDs are a heterogeneous group of disorders and the NDDs that are considered in the present systematic review and meta-analysis were selected based on prevalence rates. Since it is beyond the scope of this systematic review to describe all NDDs in detail, a short description of the NDDs that are considered in the present study will be provided. The first disorder that is considered is AD. AD is the most common NDD (Reitz et al., 2011) and is typically characterized by a progressive loss of functional independence and a gradual decline of memory. In addition, cognitive domains such as executive and visuospatial functions are often affected in people living with AD. Mild cognitive impairment (MCI) is often considered to be a prodromal stage of AD (or of other dementia's) and was, therefore, also taken into account in the present systematic review. MCI is diagnosed when there are concerns about a change in cognition, when impairments are present in one or more domains of cognition, while there is a preservation of functional independence and when the cognitive impairments are sufficiently mild that the person is not demented (Albert et al., 2011). The second most common NDD is PD which was, therefore, also taken into account in the present systematic review. PD also has a progressive decline and the diagnosis is based on the presence of motor symptoms such as rigidity, bradykinesia and tremor. Non-motor symptoms, including cognitive impairment in the domains of executive functions, attention, and visuospatial functions, are, however, also often present which can result in PD dementia (PDD) as the disease progresses (Hely et al., 2008; Litvan et al., 2011). Another common type of NDD that is closely related to PD is dementia with Lewy bodies. Dementia with Lewy bodies is also characterized by impairments in executive functions, attention, and visuospatial functions, resulting in dementia, and by motor symptoms such as bradykinesia, rigidity and tremor. However, within the context of dementia with Lewy bodies, and in contrast to PDD, dementia precedes or occurs simultaneously with the occurrence of motor symptoms (McKeith et al., 2005). Frontotemporal dementia (FTD) refers to a group of conditions which are predominately characterized by neurodegeneration of the frontal and temporal cortices. FTD is a common cause of dementia under the age of 65. The two core conditions within the context of FTD are the behavioral variant of FTD and primary progressive aphasia. The behavioral variant of FTD is characterized by changes in behavior, personality and emotion and by impairments in executive function and social cognition (Rascovsky et al., 2011), while impairments in language are the hallmark of primary progressive aphasia (Gorno-Tempini et al., 2011). Since there is a significant clinical overlap between the behavioral variant of FTD and amyotrophic lateral sclerosis (Lomen-Hoerth, 2011; Rascovsky et al., 2011), the latter was also included in the search terms. Two other NDDs that are considered in the present study are progressive supranuclear palsy and HD. People living with progressive supranuclear palsy typically show eye movement abnormalities, parkinsonian features, personality changes and cognitive impairment in the domains of executive function and attention (Litvan et al., 1996). HD is an autosomal dominant NDD that is characterized by involuntary movements, cognitive impairment in domains such as executive functions, attention and social cognition, and psychiatric features, including anxiety, aggression, disinhibition and anti-social behavior (Ross and Tabrizi, 2011). The final condition that was considered in the present systematic review was multiple sclerosis (MS). MS is an inflammatory demyelinating disorder. However, it has been argued that a degenerative process is at the root of the disease (Stys et al., 2012). Furthermore, it has been suggested that MS has a prodromal period which is similar to NDDs (Wijnands et al., 2017). MS is a common disorder in young adults and often has a progressive course. However, the condition can also develop in a relapsing remitting manner. People living with MS often show fatigue and impairments in the domains of memory, executive functions, attention and psychomotor speed (Chiaravalloti and DeLuca, 2008). The NDDs that are considered in the present systematic review and meta-analysis are thus relatively common and are accompanied by significant cognitive and psychiatric impairments, all of which can have a tremendous impact of everyday functioning, including FDM. More rare conditions such as prion diseases and corticobasal degeneration were not included in the present systematic review and meta-analysis.

2. Method

2.1. Study selection procedure

Available literature from four databases (i.e., Medline, PsychINFO, Pubmed and Web of Knowledge) was explored until December 31st, 2019 according the guidelines of Preferred Reporting Items for Systematic Reviews and Meta-Analyses (Moher et al., 2009). Primary keywords were related to NDDs, such as 'Parkinson's disease', 'mild cognitive impairment' or 'dementia'. Secondary keywords were related to FDM, including 'finances', 'financial capability' or 'money management' (for a complete list of key words see supplementary material). Keywords needed to be present in the title or abstract. Additional articles were identified through reference lists of selected articles and a recently published review focusing on currently available instruments that can be used to assess financial skills (Engel et al., 2016). Only peer-reviewed articles written in English were included. After removal of duplicates, 1612 unique articles were identified of which 129 were on topic (Fig. 1). Studies were included in the review when they (a) included a group of

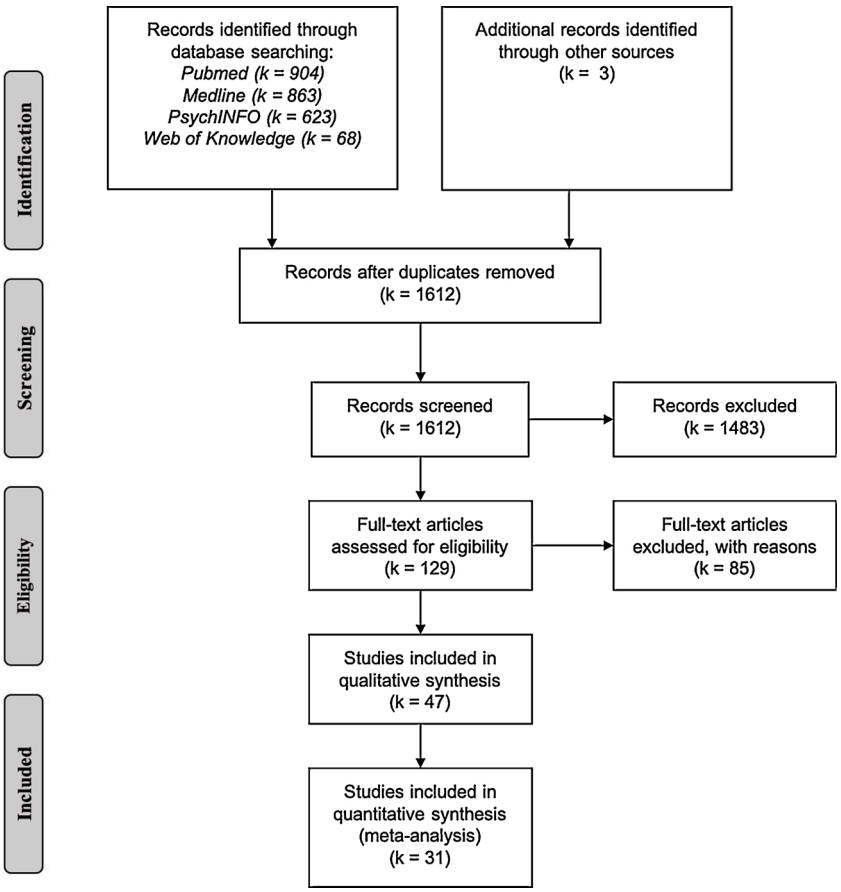

Fig. 1. Prisma flow diagram according to the guidelines of Preferred Reporting Items for Systematic Reviews and Meta-Analyses (Moher et al., 2009).

people living with an NDD and a healthy control group or when they had a longitudinal design and (b) used a standardized performance-based test of FDM (i.e., primary tests) or a performance-based general decision-making or functional capacity test with an FDM subscale (i.e., secondary tests). Studies that included a mixed group (e.g., a 'dementia group') or primarily focused on gambling or risk-taking tasks were excluded. Forty-seven studies met the inclusion criteria (Table 1; Fig. 1).

Table 1
Characteristics of included studies.

Characteristic	k	Characteristic	k
Total included studies	47	Number of studies per group[a]	
Studies including > 1 NDD group	15	AD	25 (17)
Year of publication		MCI	26 (16)
≤ 2000	5	FTD	3 (3)
2001 – 2010	13	PD	7 (5)
≥ 2011	29	MS	3 (3)
Study design		HD	1 (-)
Case-control	39	Number of participants examined per study	
Longitudinal	6	1-25	18
Both	2	26-50	14
Assessment of cognition		51-75	8
Yes	29	76-100	4
No	18	> 100	3

Note: **AD** = Alzheimer's disease; **FTD** = frontotemporal dementia; **HD** = Huntington's disease; **k** = number of studies; **MCI** = mild cognitive impairment; **MS** = multiple sclerosis; **NDD** = neurodegenerative disorder; **PD** = Parkinson's disease.

[a] Numbers in parentheses are the number of studies included in the meta-analyses.

2.2. Identified financial tests and outcome measures

The included studies used one or more performance-based tests assessing FDM. A brief description of the primary and secondary FDM tests used is given below, in alphabetical order. For a more detailed description of each test and their administration procedure we refer to the original article(s) in which the respective test has been described.

2.2.1. Primary FDM tests

1 The *Actual Reality test* (*AR test;* Goverover et al., 2010; Goverover and DeLuca, 2015) simulates the online purchase of a cookie bouquet and evaluates money management skills, such as planning and budgeting. Performances are evaluated based on (1) 'staying within price range', (2) 'correct use of credit card', (3) 'choosing an appropriate cookie bouquet', (4) 'efficient pace' and (5) 'correct response to unexpected events'. The total score is calculated based on the sum of these five goal-directed actions, with lower scores indicating better money management skills. The AR test is used in one study included in the review (i.e., Goverover et al., 2016).

2 The *Advanced Finances Test* (*AFT*; Heaton et al., 2004) evaluates the ability to manage finances using tasks involving depositing a check, paying bills and calculating checkbook balance. A total score can be calculated, with higher scores indicating a better ability to manage finances. The AFT is used in two studies included in the review (i.e., Pirogovsky et al., 2012; Sheppard et al., 2017).

3 The *Financial Assessment and Capacity Test* (FACT; Black et al., 2007) evaluates FDM capacity in elderly individuals. The FACT includes nine domains related to the conceptual model of

Appelbaum & Grisso (1988), i.e., (1) 'memory', (2) 'reading/-writing', (3) 'calculation/attention', (4) 'daily financial tasks', (5) 'general financial knowledge', (6) 'understanding assets', (7) 'financial insight', (8) 'financial confidence', and (9) 'rational beliefs about money'. Scores on all domains separately and an overall total score can be calculated, with higher scores indicating a better FDM capacity. The FACT is used in one study included in the review (i.e., Gill et al., 2019).

4 The *Financial Competence Assessment Inventory* (FCAI; Kershaw and Webber, 2008) assesses current financial competence using theoretical questions and functional tasks focused on financial abilities. The FCAI includes six domains, i.e., (1) 'everyday financial abilities', (2) 'financial judgement', (3) 'estate management', (4) 'cognitive functioning related to financial tasks', (5) 'debt management', and (6) 'support resources'. Scores on all domains separately and a total score based on the sum of all domains can be calculated. Additionally, items can be recoded in four subscales based on the conceptual model of Appelbaum & Grisso (1988), i.e., (i) 'understanding', (ii) 'appreciation', (iii) 'reasoning', and (iv) 'expressing a choice'. Higher scores indicate a better knowledge and understanding of financial competence. The FCAI is used in two studies included in this review (i.e., Gill et al., 2019; Kershaw and Webber, 2008).

5 The *Financial Capacity Instrument* (FCI; Marson et al., 2000) assesses financial knowledge and skills using tasks of different levels of complexity, such as counting coins and preparing bills. Depending on the version used, a maximum of nine domains can be differentiated with the FCI: (1) 'basic monetary skills', (2) 'financial concepts', (3) 'cash transactions', (4) 'checkbook management', (5) 'bank statement management', (6) 'financial judgment' (or 'identifying fraud'), (7) 'bill payment', (8) 'knowledge of personal assets' (or 'estate arrangements'), and (9) 'investment decision-making'. Scores can be determined for each domain separately and total scores can be calculated using different combinations of the described domains. The most frequently used combinations are a total score based on the sum of all domains, sometimes except domain 8 since this latter domain is considered to be still experimental, and a total score based on domains 2, 3, 5 and 7. One study (Gerstenecker et al., 2018) extracted four new domains of the FCI using factor analysis, i.e., (1) 'basic monetary knowledge and calculation skills', (2) 'financial judgment', (3) 'financial conceptual knowledge', and (4) 'financial procedural knowledge'. Higher scores indicate a better financial capacity. The FCI is used in twenty-two studies included in this review (i.e., Clark et al., 2014; Earnst et al., 2001; Gerstenecker et al., 2019, 2018, 2017b, 2017a, 2016; Griffith et al., 2010, 2007, 2003; Lassen-Greene et al., 2017; Marson et al., 2000; Martin et al., 2008, 2019, 2013; Niccolai et al., 2017; Okonkwo et al., 2009, 2006; Sherod et al., 2009; Stoeckel et al., 2013; Tracy et al., 2017; Triebel et al., 2009).

6 The *Financial Capacity Instrument–Short Form* (*FCI-SF;* Tolbert et al., 2019) assesses complex financial abilities and is a modified shorter version of the FCI. Five domains, i.e., (1) 'mental calculation', (2) 'financial conceptual knowledge', (3) 'single checkbook/register task', (4) 'complex checkbook/register task', and (5) 'using bank statement' are included. Scores can be determined for all five domains separately and a total score based on the sum of these five domains can be calculated, with higher scores indicating a better financial capacity. The FCI-SF is used in one study included in this review (i.e., Tolbert et al., 2019).

7 The *Financial Competency Questions* (FCQ; Bassett, 1999) evaluates a participants' understanding of financial issues related to the use and maintenance of a checking account by asking five questions. Questions require a yes or no answer and an explanation of the given answer. For each question a score is given by the examiner ranging from 0 to 5. The outcome measure is the total score on the five questions, with higher scores indicating a better understanding of financial issues. The FCQ is used in one study included in this review (i.e., Bassett, 1999).

8 The *Legal Capacity for Property Law Transactions Assessment Scale* (LCPLTAS; Giannouli et al., 2018) evaluates financial knowledge and skills by using tasks and questions focused on financial issues. The LCPLTAS is based on the theoretical model of the FCI (Marson et al., 2000) and adapted for the Greek population. The test defines seven domains, i.e., (1) 'basic monetary skills', (2) 'cash transactions', (3) 'bank statement management', (4) 'bill payment', (5) 'financial conceptual knowledge', (6) 'financial decision making', and (7) 'knowledge of personal assets'. The total score is based on all domains. Furthermore, scores on all domains separately can be calculated. Higher scores on this scale indicate better financial knowledge and skills. The LCPLTAS is used in two studies included in this review (i.e., Giannouli et al., 2018; Giannouli and Tsolaki, 2019). Furthermore, a pilot version of the LCPLTAS was presumably used in another included study (Giannouli and Tsolaki, 2014).

9 The *Numerical Activities of Daily Living–Financial* (NADL-F; Arcara et al., 2019) test is developed to evaluate independent financial functioning. The NADL-F builds on the conceptual model of Marson et al. (2000) and is based on previously published tests such as the FCAI (Kershaw and Webber, 2008) and the FCI (Marson et al., 2000). However, the NADL-F is redesigned for the socio-cultural context in Italy. The NADL-F consists of seven domains, i.e., (1) 'counting currencies', (2) 'reading abilities', (3) 'item purchase', (4) 'percentages', (5) 'financial concepts', (6) 'bill payment', and (7) 'financial judgments'. A sum score for each domain can be calculated, with higher scores indicating a better independent financial functioning. The NADL-F is used in one study included in this review (i.e., Arcara et al., 2019).

10 The *Semi-Structured Clinical Interview for Financial Capacity* (SCIFC; Marson et al., 2009) assesses financial capacity using a semi-structured interview with theoretical questions and practical performance-based items. The SCIFC is based on the theoretical model of Marson et al. (2000) and the FCI. Compared to the FCI, however, the SCIFC is briefer and easier to administer. The SCIFC consists of eight domains, i.e., (1) 'basic monetary skills', (2) 'financial conceptual knowledge', (3) 'cash transactions', (4) 'checkbook management', (5) 'bank statement management', (6) 'financial judgment', (7) 'bill payment', and (8) 'knowledge of personal financial assets and estate arrangements'. Scores on each domain and a total score based on the sum of domain 1 to 7 can be calculated (domain eight is considered to be experimental and is, therefore, not included in the total score). Higher scores indicate a better financial capacity. The SCIFC is used in one study included in this review (i.e., Marson et al., 2009).

2.2.2. Secondary tests

11 The subscale 'money management' of the *Assessment of Capacity for Everyday Decision-Making* (*ACED*; Lai et al., 2008; Lai and Karlawish, 2007) evaluates everyday financial management activities and financial management approaches. Using standardized rating criteria, scores on four decision-making abilities can be described which are based on the conceptual model of Appelbaum & Grisso (1988), i.e., (1) 'understanding', (2) 'appreciation', (3) 'reasoning', and (4) 'expressing a choice'. A total score can be calculated as the sum of four domains, with higher scores indicating better financial decision-making abilities. The subscale 'money management' of the ACED is used in one study included in this review (i.e. Lui et al., 2013).

12 The subscale 'FDM' is one of two subscales of the *Decision-Making Competence Assessment Tool* (*DMCAT*; Finucane and Gullion,

2010). Using tasks closely resembling the real-world setting, the DMCAT was developed to assess decision-making in older adults. The FDM subscale includes six items in which mutual funds must be chosen according to prespecified preferences. A total score can be calculated based on the number of correct answers, with higher scores indicating better FDM. The subscale 'FDM' of the DMCAT is used in one study included in this review (i.e., Duke Han et al., 2015).

13 The subscale 'financial skills' of the *Direct Assessment of Functional Status* (*DAFS*; Loewenstein et al., 1989; Pereira et al., 2010a) can be used as a measure of financial abilities and is described as one of the functional activities of daily living. The subscale consists of items related to identifying and counting currency and higher order financial abilities. Scores on five domains can be determined, i.e., (1) 'identifying currency', (2) 'counting currency', (3) 'writing a check', (4) 'balancing a checkbook' and (5) 'make change for a purchase', although not all studies included the fifth domain. Furthermore, a total score can be calculated based on all domains. The subscale 'financial skills' of the DAFS is used in four studies included in this review (i.e., Lima-Silva et al., 2015; Loewenstein et al., 1995, 1989; Pereira et al., 2010b).

14 The subscale 'money management' of the *Independent Living Scale* (*ILS;* Loeb, 1996) can be used to evaluate money management abilities such as counting money, performing calculations or paying bills. A total score of items associated with the subscale can be calculated, with higher scores indicating better money management abilities. The subscale 'money management' of the ILS is used in one study included in this review (i.e., Bangen et al., 2010).

15 The subscale 'bill payment' of the *Neuropsychological Assessment Battery* (*NAB;* White and Stern, 2003) is a task that simulates actions that are required when paying an utility bill, such as identifying information or filling out a check. A total score can be calculated as the sum of correct responses, with higher scores indicating better bill payment performances. The subscale 'bill payment' of the NAB is used in one study included in this review (i.e., Kenney et al., 2019).

16 The subscale 'money usage' of the *Numerical Activities of Daily Living* (*NADL*; Semenza et al., 2014) can be used to evaluate financial capacity as a function of (basic) mathematical abilities. The NADL assesses basic aspects of mathematical abilities and their impact on daily life, including the use of money. A score can be calculated based on the number of reasonably estimated prices (e.g., estimating the price of a car), with higher scores indicating better financial mathematical capacity. The subscale 'money usage' of the NADL is used in one study included in this review (i.e., Benavides-Varela et al., 2015).

17 The subscale 'money-related skills' of the *Structured Assessment of Independent Living Skills* (*SAILS*; Mahurin et al., 1991) evaluates FDM as part of a larger instrument that can be used to directly evaluate everyday activities. The subscale 'money-related skills' consists of five money-related activities, including counting money, making change, understanding a monthly utility bill, writing a check and understanding a checkbook. A total score, based on all five activities, can be calculated for the subscale with higher scores indicating better money-related skills. The subscale 'money-related skills' of the SAILS is used in one study included in this review (i.e., Mahurin et al., 1991).

18 The subscale 'finances' of the *University of California, San Diego* (*UCSD*) *performance-based skills assessment* (Patterson et al., 2001) assesses financial skills using two tasks, i.e., (1) counting coins and making change and (2) make out a check. A total score can be calculated based on the number of correct elements achieved on both tasks. Higher scores indicate better financial skills. The subscale 'finances' of the UCSD performance based skills assessment is used in two studies included in this review (i.e., Pirogovsky et al., 2014, 2013).

19 The subscale 'money management' of the *University of Miami computer-based functional assessment battery* (*UMCFAB;* Czaja et al., 2017) evaluates money management abilities using a computer-based replication of an Automatic Teller Machine (ATM). The performance-based ATM requires individuals to perform money related actions, such as checking the balance in their savings account, transferring money or withdrawing cash from their savings account. Different scores can be calculated, i.e., 'total correct answers', 'total incorrect answers', 'task completion time' and 'an efficiency/rate score based on total correct answers divided by task completion time'. The subscale 'money management' of the UMCFAB is used in one study included in this review (i.e., Czaja et al., 2017).

2.3. Study analysis

2.3.1. Content analysis

A content analysis approach was applied to the included studies. The results were organized and extracted in table format for each disorder separately displaying demographics and disease characteristics of the included samples. In addition, primary outcome measures and the most important results of each paper relevant for the research questions at hand are described (Tables 2a–2f). Some studies describe the use of participants from the same study cohort, i.e., from the *Cognitive Observations in Seniors Study* (*COINS*; Clark et al., 2014; Gerstenecker et al., 2019, 2018, 2017a, 2016; Niccolai et al., 2017) or the *Measuring Independent Living in the Elderly Study* (*MILES*; Lassen-Greene et al., 2017; Okonkwo et al., 2009, 2006). However, despite the same study cohort has been used, there is insufficient evidence that the same sample has been used in these studies and, therefore, these studies are treated and described as separate studies in the content and meta-analysis. Two studies focused on people living with PD (Pirogovsky et al., 2014, 2013). However, these studies did use the same sample and are, therefore, considered and described as one study within the present systematic review. Of longitudinal studies, baseline data (if applicable) are used for cross-sectional comparisons. However, one research group performed a follow-up at one-year (Martin et al., 2008; Triebel et al., 2009), two-years (Clark et al., 2014; Gerstenecker et al., 2016) and six-years (Martin et al., 2019) of the same sample and, therefore, only the baseline data of people living with AD and people living with MCI as described in Martin et al. (2019) was used to evaluate cross-sectional data. In the content analysis, group differences were considered significant when alpha $< .05$, independent of the used alpha level in the original study. Two studies, however, did not describe the p-values of their group comparisons and used a more conservative alpha level to evaluate significance (Marson et al., 2000; Tracy et al., 2017). Potential significant results using a less conservative p-value could, therefore, not be determined for these studies and included in this systematic review. Correlations were interpreted as weak when $r = .30$, moderate when $r = .50$ and strong when $r = .70$ (Fritz et al., 2012).

2.3.2. Meta-analysis

In addition, a meta-analysis was performed for each NDD group separately when more than one of the included studies focused on a particular group. In the meta-analyses, the total scores (i.e., sum of domains or items) of the FDM tests were used. Therefore, studies that did not report total scores (Arcara et al., 2019; Czaja et al., 2017; Gerstenecker et al., 2018; Giannouli and Tsolaki, 2014; Marson et al., 2000; Okonkwo et al., 2006, 2009) and studies that did not provide means and/or standard deviations for total scores (Mahurin et al., 1991; Marson et al., 2009; Sheppard et al., 2017) were excluded from the meta-analysis. Furthermore, two studies did not include a healthy control group (Gerstenecker et al., 2016; Loewenstein et al., 1995) and were, therefore, not used in the meta-analysis. Regarding longitudinal

Table 2a
Overview of studies measuring financial decision-making in people living with Alzheimer's disease (k = 25).

Study	Country	Design	Sample characteristics		FDM task (scale)	Main outcome	Conclusion
Bassett (1999)	USA	CS	**AD** (n = 20) / Stage: mild/moderate - age (y) 75.3 ± 9.9 - education n.r. - 20.0% male **HC** (n = 20) - age (y) 75.2 ± 5.9 - education (y) 13.6 ± 2.4 - 30.0% male	- MMSE 22.0 ± 4.2 - CDR 0.5 to 2.0 - n.r.	**FCQ** (total score)	- People living with mild/moderate AD showed a significantly lower FDM performance than HC on the FCQ total score. - 55% of People living with mild/moderate AD were classified as incompetent (≤ 2SD below the mean of controls) based on the FCQ total score.	AD (mild/moderate) < HC
Clark et al. (2014)[+]	USA	LS	**AD** (n = 41) / Stage: mild - age (y) 72.5 ± 6.0 - education (y) 14.0 ± 3.0 - 63.4% male **HC** (n = 44) - age (y) 70.5 ± 7.1 - education (y) 14.4 ± 2.2 - 38.6% male	- MMSE 24.3 ± 3.4* - DRS 119.1 ± 9.7* - MMSE 29.3 ± 1.2 - DRS 138.9 ± 3.9	**FCI** (total score based on domains 1-7, 9)	- 46% (5/11) and 20% (1/5) of people living with mild AD showed significant decline (≥10 points difference) compared to baseline after 1 and 2 years, respectively. - In contrast, 15.8% (6/38) and 17.6% (6/34) of HC showed significant decline (≥10 points difference) compared to baseline after 1 and 2 years, respectively.	N/A
Earnst et al. (2003)	USA	CS	**AD** (n = 20) / Stage: mild/moderate - age (y) 71.9 ± 7.2 - education (y) 13.3 ± 2.9 - % male n.r. **HC** (n = 23) - age (y) 71.0 ± 9.2 - education (y) 14.6 ± 1.9 - % male n.r.	- MMSE 20.5 ± 4.8[?] - MMSE 28.8 ± 0.8	**FCI** (scores on domains 1-7, total score based on domains 1-7)	- People living with mild/moderate AD showed significantly lower FDM performances than HC on the FCI total score and on all domains separately.	AD (mild/moderate) < HC
Gerstenecker et al. (2017a)[+]	USA	CS	**AD** (n = 39) / Stage: mild - age (y) 71.3 ± 8.0 - education (y) 14.1 ± 2.6* - 51.2% malea **HC** (n = 60) - age (y) 70.6 ± 7.0 - education (y) 16.0 ± 2.3 - 72.1% male[a]	- MMSE 21.7 ± 5.1* - DRS 113.9 ± 12.9* - MMSE 29.1 ± 1.2 - DRS 138.9 ± 2.8	**FCI** (scores on domains 1-7, total score based on domains 1-7)	- People living with mild AD showed significantly lower FDM performances than HC on the FCI total score and on all domains separately.	AD (mild) < HC
Gerstenecker et al. (2018)[+]	USA	CS	**AD** (n = 112) / Stage: mild - age (y) n.r. - education (y) n.r. - % male n.r. **HC** (n = 179) - age (y) n.r. - education (y) n.r. - % male n.r.	- n.r. - n.r.	**FCI** (scores on 4 domains extracted from factor analyses)	- People living with mild AD showed significantly lower FDM performances than HC on all domains.	AD (mild) < HC
Gerstenecker et al. (2019)[+]	USA	CS	**AD** (n = 59) / Stage: mild - age (y) 74.5 ± 8.7 - education (y) 14.5 ± 2.3 - 54.2% male **HC** (n = 64) - age (y) 70.6 ± 7.4 - education (y) 15.8 ± 2.3 - 29.7% male	- MMSE 23.7 ± 3.1* - MMSE 28.7 ± 3.9	**FCI** (scores on domains 1-7, 9, total score based on domains 1-7, 9)	- People living with mild AD showed significantly lower FDM performances than HC on the FCI total score and on all domains separately.	AD (mild) < HC
Giannouli & Tsolaki (2014)[+]	Greece	CS	**AD** (n = 10) / Stage: severe - age (y) 74.4 ± 8.6? - education (y) 5.65 ± 2.6? - % male n.r. **AD** (n = 22) / Stage: moderate - age (y) 77.8 ± 6.1? - education (y) 7.4 ± 4.0?	- MMSE 5.4 ± 2.8[?] - MMSE 15.2 ± 2.4?	**FDM test**[b] (scores on six domains)	- All people living groups showed significantly lower FDM performances than HC (i.e., < 2.5SD below the mean of controls) on all domains of the FDM test. - People living with severe AD showed significantly lower FDM performances than people living with mild AD (i.e., < 2.5SD below the mean of people living with mild AD) on three domains of the FDM test, i.e., 'basic monetary skills', decision making capacity and judgment for different dilemmas.	AD (severe) < AD (moderate) < AD (mild) < HC

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Table 2a (*continued*)

Study	Country	Design	Sample characteristics		FDM task (scale)	Main outcome	Conclusion
			- % male n.r. **AD** (n = 32) / Stage: mild - age (y) 76.7 ± 7.4? - education (y) 6.9 ± 4.3? - % male n.r. **HC** (n = 83) - age (y) 73.6 ± 9.8 - education (y) 8.1 ± 4.6 - % male n.r. **AD** (n = 23) / Stage: severe - age (y) n.r.c - education (y) n.r.c - % male n.r.[c] **AD** (n = 20) / Stage: moderate - age (y) n.r.c - education (y) n.r.c - % male n.r.[c] **AD** (n = 21) / Stage: mild - age (y) n.r.c - education (y) n.r.c - % male n.r.c **HC** (n = 22) - age (y) n.r.c - education (y) n.r.c - % male n.r.[c]	- MMSE 22.2 ± 2.6? - MMSE 29.5 ± 1.2 - MMSE 5.6 ± 3.2[?] - MMSE 14.7 ± 2.6[?] - MMSE 21.8 ± 2.1? - MMSE 29.2 ± 0.9		- People living with severe AD also showed significantly lower FDM performances than people living with moderate AD (i.e., < 2.5SD below the mean of people living with moderate AD) on one domain of the FDM test, i.e., 'decision making capacity and judgment for different dilemmas'. - People living with moderate AD showed significantly lower FDM performances than people living with mild AD (i.e., < 2.5SD below the mean of people living with mild AD) on one domain of the FDM test, i.e., 'decision making capacity and judgment for different dilemmas'.	
Giannouli et al. (2018)[+]	Greece	CS			**LCPLTAS** (scores on seven domains, total score based on all domains)	- All people living groups showed significantly lower FDM performance than HC on the LCPLTAS total score and on all domains separately. - People living with severe AD showed significantly lower FDM performances than people living with mild or moderate AD on the LCPLTAS total score and on all domains separately. - People living with moderate AD showed significantly lower FDM performances than people living with mild AD on the LCPLTAS total score and on all domains separately.	AD (severe) < AD (moderate) < AD (mild) < HC
Gill et al. (2019)[+]	Canada[++]	CS	**AD** (n = 15) / Stage: n.r. - age (y) 77.3 ± 6.4* - education (y) 14.2 ± 4.4 - 66.7% male[?] **HC** (n = 20) - age (y) 67.9 ± 8.9 - education (y) 13.7 ± 2.9 - 40.0% male	- MoCA 17.4 ± 4.0* - MoCA 27.3 ± 1.9	**FACT** (scores on eight domains and total score based on all domains) & **FCAI** (scores on six domains, total score based on all domains)	- People living with AD showed a significantly lower FDM performance than HC on the FACT domain 'memory'. No group differences were found for the total score and for all other domains. - People living with AD showed a significantly lower FDM performance than HC on the FCAI total score and on all domains separately, with the exception of 'debt management'.	AD ≤ HC
Griffith et al. (2003)[+]	USA	CS	**AD** (n = 22) / Stage: mild - age (y) 71.5 ± 9.2 - education (y) 14.5 ± 2.5 - 40.1% male **HC** (n = 21) - age (y) 66.7 ± 7.2 - education (y) 14.3 ± 2.7 - 33.3% male	- MMSE 24.1 ± 2.6* - DRS 115.3 ± 11.1* - CDR 1.0* - MMSE 29.3 ± 1.0 - DRS 137.4 ± 4.3 - CDR 0.0 or 0.5	**FCI** (scores on domains 1-9, total score based on domains 1-7)	- People living with mild AD showed significantly lower FDM performances than HC on the FCI total score and on all domains separately, with the exception of 'assets and estate'.	AD (mild) ≤ HC
Griffith et al. (2007)	USA	CS	**AD** (n = 14) / Stage: mild - age (y) 75.9 ± 8.0 - education (y) 15.0 ± 2.8 - 57.1% male **HC** (n = 14) - age (y) 71.0 ± 4.2 - education (y) 14.2 ± 2.2 - 28.6% male	- MMSE 25.0 ± 2.5* - DRS 117.7 ± 10.4* - CDR 0.5 or 1.0* - MMSE 29.7 ± 0.5 - DRS 137.9 ± 2.4 - CDR 0	**FCI** (total score based on domains 2, 5-7)	- People living with mild AD showed a significantly lower FDM performance than HC on the FCI total score. - FDM (total score of the FCI) was mildly to moderately negatively correlated with neural tissue loss or damage (NAA/Cr ratio) and neural demyelination (Cho/Cr ratio).	AD (mild) < HC
Kershaw & Webber (2008)	Australia	CS	**AD** (n = 22) / Stage: n.r. - age (y) 83.0 ± 5.3* - education (y) ≈ 9* - 13.6% male[?] **HC** (n = 59) - age (y) 52.5 ± 19.3 - education (y) ≈ 12	- MMSE 16.9 ± 4.5[?] - MMSE 29.6 ± 0.5	**FCAI** (scores on six domains, total score based on all domains)	- People living with AD showed significantly lower FDM performances than HC on the FCAI total score and on all domains separately, with the exception of 'support resources'. The degree of impairment of people living with AD was > 1.5SD below the mean of HC.	AD ≤ HC

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Table 2a (*continued*)

Study	Country	Design	Sample characteristics		FDM task (scale)	Main outcome	Conclusion
Lima-Silva et al. (2015)[+]	Brazil	CS	- 40.0% male **AD** (n = 30) / Stage: n.r. - age (y) 68.7 ± 6.8 - education (y) 8.6 ± 4.5 - 56.7% male **HC** (n = 34) - age (y) 65.4 ± 5.9 - education (y) 9.6 ± 3.9 - 62.8% male	- MMSE 19.2 ± 2.3* - CDR 1.0 - MMSE 25.5 ± 1.3 - CDR n.r.	**Subscale 'financial skills' of DAFS** – Brazilian version (total score based on five domains)	- People living with AD showed a significantly lower FDM performance than HC on the 'financial skills' total score.	AD < HC
Loewenstein et al. (1989)	USA	CS	**AD** (n = 12) / Stage: n.r. - age (y) 78.2 ± 10.1 - education (y) n.r. - 58.3% male[?] **HC** (n = 18) - age (y) 75.4 ± 5.7 - education (y) 13.8 ± 2.7 - 27.8% male	- n.r. - MMSE 28.0 ± 2.2	**Subscale 'financial skills' of DAFS** (scores on four domains, total score based on all domains)	- People living with AD showed significantly lower FDM performances than HC on the total score of the 'financial skills' subscale and on all domains separately, with the exception of 'identifying change'.	AD ≤ HC
Loewenstein et al. (1995)	USA	LS	**AD**(n = 52) / Stage: n.r. - age (y) 76.6 ± 7.2 - education (y) 12.4 ± 3.8 - 38.5% male no HC group	- MMSE 19.0 ± 4.7[d]	**Subscale 'financial skills' of DAFS** (scores on four domains)	- People living with AD showed a significant deterioration after 1 year on all FDM domains, with the exception of 'balancing a checkbook'.	N/A
Lui et al. (2013)[+]	China[+]	CS	**AD** (n = 90) / Stage: mild - age (y) 82.2 ± 6.6* - education (y) 1.7 ± 3.3* - 15.6% male§ **HC** (n = 93) - age (y) 74.2 ± 6.5 - education (y) 4.3 ± 3.7 - 10.8% male	- MMSE 19.7 ± 2.5* - MMSE 26.6 ± 2.5	**'money management' version of ACED** – Chinese version (scores on four domains, total score based on all four domains)	- People living with mild AD showed significantly lower FDM performances than HC on the 'money management' total score and on all domains separately.	AD (mild) < HC
Mahurin et al. (1991)	USA	CS	**AD** (n = 18) / Stage: n.r. - age (y) 66.9 ± 5.4 - education (y) 14.1 ± 2.5 - 50.0% male **HC** (n = 18) - age (y) 66.6 ± 6.4 - education (y) 14.0 ± 2.6 - 50.0% male	- MMSE 19.4 ± 3.4* - GDS 3.6* - MMSE 29.0 ± 0.9 - GDS 1.0	**Subscale 'money-related skills' of SAILS** (total score)	People living with AD showed a significantly lower FDM performance than HC on the total score of the 'money-related skills' subscale.	AD < HC
Marson et al. (2000)	USA	CS	**AD** (n = 50) / Stage: mild (n = 30) and moderate (n = 20) - age (y) 75.2 ± 5.9 - education (y) 12.8 ± 3.3* - 38.0% male - HC (n = 23) - age (y) 70.3 ± 6.7 - education (y) 15.2 ± 1.8 - 39.1% male	- MMSE 20.4 ± 4.4[?] - MMSE 29.2 ± 0.9	**FCI** (scores on domains 1-6)	- People living with mild AD showed significantly lower FDM performances than HC on all domains of the FCI, with the exception of 'basic monetary skills'. - People living with moderate AD showed significantly lower FDM performances than HC on all domains of the FCI. - People living with moderate AD showed significantly lower FDM performances than people living with mild AD on all domains of the FCI.	AD (moderate) < AD (mild) ≤ HC
Marson et al. (2009)[+]	USA	CS	**AD** (n = 31) / Stage: moderate - age (y) 75.3 ± 8.4* - education (y) 11.1 ± 3.7*§ - 32.3% male*§ **AD** (n = 97) / Stage: mild - age (y) 72.4 ± 8.4* - education (y) 13.4 ± 2.1* - 53.6% male **HC** (n = 75) - age (y) 66.1 ± 7.7	- MMSE 16.4 ± 4.2*§ - DRS 90.7 ± 19.6*§ - CDR 1.0 to 3.0[?] - MMSE 24.0 ± 3.1* - DRS 114.0 ± 12.1* - CDR 0.5 to 1.0[?] - MMSE 29.3 ± 1.0	**SCIFC** (scores on domains 1-8, total score based on domains 1-7)	- People living with moderate AD were more often marginally capable or incapable regarding FDM than HC on the SCIFC total score and on all domains separately. - People living with mild AD were more often marginally capable or incapable regarding FDM than HC on the SCIFC total score and on all domains separately, with the exception of 'basic monetary skills'. - People living with moderate AD were more often marginally capable or incapable regarding FDM than people living with mild AD on the SCIFC total score and on all domains separately, with the exception of 'checkbook management' and 'bill payment'.	AD (moderate) ≤ AD (mild) ≤ HC

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Table 2a (*continued*)

Study	Country	Design	Sample characteristics		FDM task (scale)	Main outcome	Conclusion
			- education (y) 14.3 ± 1.6 - 32.0% male **AD** (n = 55) / Stage: mild - age (y) 70.6 ± 8.4* - education (y) 13.1 ± 2.3* - 56.4% male*	- DRS 138.7 ± 3.8 - CDR 0.0 or 0.5 - MMSE 24.5 ± 3.1* - DRS 116.2 ± 10.5* - CDR 0.5 or 1.0*			
Martin et al. (2008)	USA	LS	**HC** (n = 63) - age (y) 66.3 ± 7.6 - education (y) 14.4 ± 1.7 - 31.7% male	- MMSE 29.3 ± 1.0 - DRS 136.7 ± 4.8 - CDR 0e	**FCI** (scores on domains 1-9, total score based on domains 1-7, total score based on domains 1-8)	- People living with mild AD showed a significant deterioration after 1 year on the FCI total scores and on all domains separately. No significant deterioration was observed in HC.	N/A
			AD (n = 54) / Stage: mild - age (y) 73.3 ± 8.2* - education (y) 13.7 ± 3.2* - 53.7% male	- MMSE 24.5 ± 3.2* - DRS 118.4 ± 12.0* - CDR 0.5 to 1.0			
Martin et al. (2019)[+]	USA	CS	**HC** (n = 82) - age (y) 66.3 ± 8.5 - education (y) 15.2 ± 2.5 - 36.6% male	- MMSE 29.5 ± 0.9 - DRS 138.9 ± 3.7 - CDR 0.0 or 0.5	**FCI** (scores on domains 1-9, total score based on domains 1-7, total score based on domains 1-7, 9)	- People living with mild AD showed significantly lower FDM performances than HC on the FCI total scores and on all domains separately.	AD (mild) < HC
			AD (n = 26) / Stage: n.r. - age (y) 77.9 ± 6.0* - education (y) 8.8 ± 5.5* - 42.0% male[?]	- MMSE 19.5 ± 5.5*	**Subscale 'financial skills' of DAFS** – Brazilian version (total score)	- People living with AD showed a significantly lower FDM performance than HC on the total score of the 'financial skills' subscale.	AD < HC
Pereira et al. (2010b)[+]	Brazil	CS	**HC** (n = 32) - age (y) 71.6 ± 5.6 - education (y) 13.3 ± 6.0 - 25.0% male	- MMSE 28.8 ± 1.5			
			AD (n = 43) / Stage: mild - age (y) 73.8 ± 8.5* - education (y) 13.6 ± 2.9* - 55.8% male	- MMSE 24.6 ± 2.9* - DRS 118.7 ± 10.2* - CDR 0.5 to 2.0*			
Sherod et al. (2009)[+]	USA	CS	**HC** (n = 85) - age (y) 67.2 ± 8.2 - education (y) 15.0 ± 2.4 - 35.3% male	- MMSE 29.4 ± 0.9 - DRS 138.8 ± 3.3 - CDR 0 or 0.5	**FCI** (total score based on domains 1-7)	- People living with mild AD showed a significantly lower FDM performance than HC on the FCI total score.	AD (mild) < HC
			AD (n = 16) / Stage: mild - age (y) 77.0 ± 8.2 - education (y) 14.3 ± 2.5 - 43.8% male	- MMSE 25.1 ± 1.8* - DRS 118.4 ± 13.2* - CDR 0.5 or 1.0*			
Stoeckel et al. (2013)	USA	CS	**HC** (n = 16) - age (y) 75.0 ± 4.4 - education (y) 14.3 ± 2.8 - 31.3% male	- MMSE 29.4 ± 0.7 - DRS 137.4 ± 2.5 - CDR 0	**FCI** (total score based on domains 2, 5-7)	People living with mild AD showed a significantly lower FDM performance than HC on the FCI total score. FDM was moderately positively correlated with grey matter volumes (MRI) of medial frontal cortex, dorsolateral frontal cortex, precuneus and the angular gyri in people living with mild AD. No significant correlation between grey matter volume (MRI) of hippocampi and FDM was found in people living with mild AD.	AD (mild) < HC
			AD (n = 20) / Stage: mild - age (y) 74.8 ± 6.5* - education (y) 15.5 ± 2.7* - 55.0% male	- MMSE 24.3 ± 3.6* - CDR 0.5 or 1.0?			
Tolbert et al. (2019)[+]	USA	CS	**HC** (n = 144) - age (y) 71.6 ± 6.2 - education (y) 16.8 ± 2.4 - 48.0% male	- MMSE 29.1 ± 1.0 - CDR 0	**FCI – SF** (score on 5 domains and total score based on all domains)	• People living with mild AD showed a significantly lower FDM performance than HC on the FCI – SF total score and on all domains separately. • FDM was mildly to moderately negatively correlated to ß-amyloid SUVr in people living with mild AD.	AD (mild) < HC

Note. All results are considered significant when $p < .05$.

ACED = Assessment of Capacity for Everyday Decision-making; **AD** = Alzheimer's disease; **CS** = Cross-Sectional study; **CDR** = Clinical Dementia Rating; **Cho/Cr ratio** = Choline-containing compounds/Creatine ratio; **DAFS** = Direct Assessment of Functional Status; **DRS** = Dementia Rating Scale; **FACT** = Financial Assessment and Capacity Test; **FCAI** = Financial Competence Assessment Inventory; **FCI** = Financial Capacity Instrument; **FCI-SF** = Financial Capacity Instrument – Short Form; **FCQ** = Financial Competency Questions; **FDM** = Financial Decision-Making; **GDS** = Global Deterioration Scale; **HC** = Healthy controls; **LCPLTAS** = Legal Capacity for Property Law Transactions Assessment Scale; **LS** = Longitudinal study; **MMSE** = Mini-Mental State Examination; **MoCA** = Montreal Cognitive Assessment; **MRI** = Magnetic Resonance Imaging; **n.r.** = not reported; **N/A** = not applicable; **NAA/CR ratio** = N-Acetylaspartate/Creatine ratio; **SAILS** = Structured Assessment of Independent Living Skills; **SCIFC** = Semi-Structured Clinical Interview for Financial Capacity; **SUVr** = Standardized

Uptake Value ratio.
[a]Percentage male cited from original article, however, the sum of the number of males and females in article does not correspond with total number of participants.
[b] No official name of test reported, test is likely a pilot version of the LCPLTAS.
[c] Participants were matched based on sex, level of education and age.
[d] Not described in original article whether global cognition score(s) reflect baseline or follow-up.
+ Study included more than one NDD group.
++ In collaboration with authors from other countries.
* Significant difference between people living with AD and HC.
§ Significant difference with other NDD group(s).
? Group differences not analyzed/reported.
< Performances significantly worse on all FDM outcome measures.
≤ Performances significantly worse on some FDM outcome measures, but not all.

studies, only the baseline results were used for the meta-analysis. Furthermore, only the most recent published study was used in the meta-analysis of the two PD studies that presumably used the same sample (Pirogovsky et al., 2014, 2013). In total, thirty-one studies were included in the meta-analysis (Table 1; Fig. 1). When studies included more than one subgroup (e.g., MCI converters and MCI non-converters) and/or used more than one FDM test or total score, a combined fixed effect size was calculated (Borenstein et al., 2009). Using Comprehensive Meta-Analysis software version 2.2.064 the pooled mean effect size (method: random) was calculated for each group. Hedges' g was considered small when $g = .20$, medium when $g = .50$ and large when $g = .80$ (Fritz et al., 2012). Funnel plot asymmetry was tested with a regression method to evaluate publication bias (Egger et al., 1997). Finally, heterogeneity was evaluated by calculating the I^2 value. I^2 values of 25%, 50% and 75% were interpreted as low, moderate and high heterogeneity, respectively (Higgins et al., 2003).

3. Results

3.1. Alzheimer's Disease (AD)

Twenty-five studies investigated FDM in people living with AD (Table 2a), evaluating 1086 people living with AD in total. Participants' average age ranged from 66.9 to 83.0 years (weighted average = 74.8 years). Most studies included people living with AD who were in a mild and/or moderate stage of the disease, two studies also included a group of people in a severe stage of AD (Giannouli et al., 2018; Giannouli and Tsolaki, 2014). Seven studies, however, did not specify the stage of the disease (Gill et al., 2019; Kershaw and Webber, 2008; Lima-Silva et al., 2015; Loewenstein et al., 1995, 1989; Mahurin et al., 1991; Pereira et al., 2010b).

All cross-sectional studies on AD reported significantly lower performances on performance-based tests of FDM in people living with AD compared to healthy controls (Table 2a). This corresponds to the overall large pooled mean effect size for the difference between people living with AD and healthy controls that was found in the meta-analysis ($g = 2.69$ [2.15; 3.23], $SE = 0.27$, $p < .001$ based on 17 studies; Fig. 2). Significant heterogeneity was found ($Q(16) = 246.6$, $p < .001$, $I^2 = 93.5\%$). More than half of the studies that were included in the meta-analysis used the FCI (n = 9). Studies using the FCI reported a significantly lower overall effect size ($g = 2.17$ [1.40; 2.94], $SE = 0.39$, $p < .001$) compared to the studies using FDM tests other than the FCI ($g = 3.33$ [2.49; 4.16], $SE = 0.43$, $p < .001$; $Q(1) = 4.00$, $p = .045$). The effect size of three studies using FDM tests other than the FCI are, compared to the other studies, relatively high ($g = 9.63$ (Giannouli et al., 2018), $g = 5.02$ (Kershaw and Webber, 2008) and $g = 4.03$ (Lima-Silva et al., 2015); Fig. 2). Nevertheless, the overall effect size remained large and significant when these studies are excluded ($g = 2.05$ [1.77; 2.33], $SE = 0.14$, $p < .001$ based on 14 studies). The difference between studies using the FCI compared to the remaining studies is, however, no longer significant after excluding these studies (n = 5, $g = 1.80$ [1.35; 2.25], $SE = 0.23$, $p < .001$; $Q(1) = 1.86$, $p = .173$). The funnel plot showed significant asymmetry ($p = .015$; Fig. 3) with a slight right skewed distribution. After removal of the three studies with relatively high effect sizes, the funnel plot asymmetry was no longer significant ($p = .476$).

The content analysis of the included studies that described the stage of the disease of included participants indicates that relatively simple aspects of FDM (e.g., 'identifying currency' and 'naming coins') seem to be intact in people living with mild AD, since no differences between people living with mild AD and healthy controls were found regarding these specific domains in some of the studies (Griffith et al., 2003; Loewenstein et al., 1989; Marson et al., 2009, 2000). However, other studies did find significantly lower performances in people living with mild AD, compared to healthy controls, on similar domains of FDM (Gerstenecker et al., 2019, 2017a; Martin et al., 2008). Furthermore, overall FDM performance (reflected by total scores) was significantly

Table 2b
Overview of studies measuring financial decision-making in people living with mild cognitive impairment (k = 26).

Study	Country	Design	Sample characteristics	FDM task (scale)	Main outcome	Conclusion
Arcara et al. (2019)	Italy	CS	**MCI** (n = 40) / Type: n.r. - age (y) n.r.a - education (y) n.r.[a] - 50.0% male **HC** (n = 40) - age (y) n.r.a - education (y) n.r.a - 37.5% male - n.r.	**NADL-F test** (scores on seven domains)	- People living with MCI showed a significantly lower FDM performance than HC on all domains of the NADL-F test, with the exception of 'reading abilities', 'purchase' and 'financial judgments'.	MCI ≤ HC
Bangen et al. (2010)	USA	CS	**MCI** (n = 22) / Type: amnestic - age (y) 74.9 ± 7.1 - education (y) 16.5 ± 2.13 - 36.4% male - MCI (n = 16) / Type: non-amnestic age (y) 77.1 ± 8.5 education (y) 15.2 ± 3.2 62.5% male **HC** (n = 82) - age (y) 74.3 ± 9.4 - education (y) 16.0 ± 2.3 - 63.4% male - DRS 49.8 ± 5.7* DRS 51.3 ± 5.4* - DRS 55.4 ± 4.5	**Subscale 'managing money' of ILS** (total score)	- People living with amnestic MCI showed significantly lower FDM performances than HC on total score of the 'managing money' subscale. - No differences were found between people living with non-amnestic MCI and HC. - No differences were found between people living with amnestic MCI and people living with non-amnestic MCI.	MCI (amnestic) < HC MCI (non-amnestic) = HC MCI (amnestic) = MCI (non-amnestic)
Benavides-Varela et al. (2015)	Italy	CS	**MCI** (n = 33) / Type: n.r. - age (y) 74.4 ± 6.0* - education n.r. - 60.6% male **HC** (n = 29) - age (y) 67.1 ± 8.4 - education n.r. - 37.9% male - MMSE 26.6 ± 2.5* - MMSE 29.1 ± 8.4	**Subscale 'money usage' of NADL** (total score)	- People living with MCI showed a significantly lower FDM performance than HC on the total score of the NADL 'money usage' subscale.	MCI < HC
Clark et al. (2014)[+]	USA	LS	**MCI converters** (n = 44) / Type: n.r. - age (y) 72.8 ± 6.3 - education (y) 14.6 ± 3.2 - 45.5% male **MCI non-converters** (n = 36) / Type: n.r. - age (y) 71.5 ± 6.2 - education (y) 14.8 ± 2.9 - 38.9% male **HC** (n = 44) - age (y) 70.5 ± 7.1 - education (y) 14.4 ± 2.2 - MMSE 27.2 ± 1.9** - DRS 129.0 ± 7.1** - MMSE 28.4 ± 1.7** - DRS 133.7 ± 5.8** - MMSE 29.3 ± 1.2 - DRS 138.9 ± 3.9	**FCI** (total score based on domains 1-7, 9)	- 35% (15/43) and 32% (11/34) of MCI converters showed significant decline (≥ 10 points difference) compared to baseline after 1 and 2 years, respectively. - 21% (7/34) and 21% (7/33) of MCI non-converter showed significant decline (≥ 10 points difference) compared to baseline after 1 and 2 years, respectively. - In contrast, 15.8% (6/38) and 17.6% (6/34) of HC showed significant decline (≥10 points difference) compared to baseline after 1 and 2 years, respectively.	N/A

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Table 2b (*continued*)

Study	Country	Design	Sample characteristics	FDM task (scale)	Main outcome	Conclusion
Czaja et al. (2017)	USA	CS	- 38.6% male **MCI** (n = 62) / Type: amnestic age (y) 75.9 ± 7.7* education 14.6 ± 4.0 33.0% male **HC** (n = 85) - age (y) 72.0 ± 8.3 - education (y) 14.5 ± 3.2 - 23.0% male **MCI** (n = 114) / Type: n.r. - age (y) 84.3 ± 6.1* - education (y) 15.4 ± 3.0 - 30.6% male* **HC** (n = 586) - age (y) 81.1 ± 7.8 - education (y) 15.2 ± 3.1 - 22.7% male **MCI** (n = 51) / Type: n.r. - age (y) 71.0 ± 6.6 - education (y) 14.9 ± 3.3 - 54.9% male no HC group **MCI** (n = 31) / Type: amnestic - age (y) 71.9 ± 7.1 - education (y) 15.2 ± 2.5 - 69.7% male **HC** (n = 60) - age (y) 70.6 ± 7.0 - education (y) 16.0 ± 2.3 - 72.1% male **MCI** (n = 149) / Type: amnestic - age (y) n.r. - education (y) n.r. - % male n.r. **HC** (n = 179) - age (y) n.r. - education (y) n.r.	- CDR 0.5 - CDR 0 - Global cognition z-score -0.3 ± 1.4[b]* - Global cognition z-score 0.4 ± 0.4b - Baseline: - MMSE 27.6 ± 1.9 - DRS 130.9 ± 7.3 - Year 2: - MMSE 25.9 ± 4.2 - DRS 124.8 ± 14.6 - 9 participants converted to AD - MMSE 26.9 ± 2.1* - DRS 130.7 ± 4.9* - MMSE 29.1 ± 1.2 - DRS 138.9 ± 2.8 - n.r. - n.r.	**Subscale 'money management' of the UMCFAB** (total number of correct answers, total number of errors, and efficiency score)	- People living with MCI showed lower FDM performances than HC on all scores. - 40% and 34% of people living with amnestic MCI were classified as impaired (i.e., ≤ 2SD below the mean of controls) based on the 'total number of correct answers' and 'total number of errors', respectively.	MCI (amnestic) < HC
Duke Han et al. (2015)	USA	CS		**Subscale FDM of DMCAT** (total score)	- People living with MCI showed significantly lower FDM performances than HC on the total score.	MCI < HC
Gerstenecker et al. (2016)	USA	LS		**FCI** (scores on domains 1-7, 9)	- People living with MCI showed a significant deterioration regarding FDM in the domains 'checkbook management', 'bank statement management', 'bill payment' and 'investment decision-making'.	N/A
Gerstenecker et al. (2017a)[+]	USA	CS		**FCI** (scores on domains 1-7, total score based on domains 1-7)	- People living with MCI showed significantly lower FDM performances than HC on the FCI total score and on all domains separately, with the exception of 'basic money skills' and 'identifying fraud/financial judgment'.	MCI (amnestic) ≤ HC
Gerstenecker et al. (2018)[+]	USA	CS		**FCI** (scores on 4 domains extracted from factor analyses)	People living with MCI showed significantly lower FDM performances than HC on all domains, with the exception of one which was described as 'financial conceptual knowledge'.	MCI (amnestic) ≤ HC

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Table 2b (*continued*)

Study	Country	Design	Sample characteristics	FDM task (scale)	Main outcome	Conclusion
Gerstenecker et al. (2019)[+]	USA	CS	- % male n.r. **MCI** (n = 65) / Type: amnestic - age (y) 72.6 ± 7.4 - education (y) 15.2 ± 2.6 - 49.2% male **HC** (n = 64) - age (y) 70.6 ± 7.4 - education (y) 15.8 ± 2.3 - 29.7% male - MMSE 27.4 ± 3.2* - MMSE 28.7 ± 3.9	**FCI** (scores on domains 1-7, 9, total score based on domains 1-7, 9)	- People living with MCI showed significantly lower FDM performances than HC on the FCI total score and on all domains separately, with the exception of 'basic money skills' and 'identifying fraud/financial judgment'.	MCI (amnestic) ≤ HC
Giannouli & Tsolaki (2014)[+]	Greece	CS	**MCI** (n = 46) / Type: amnestic - age (y) 69.7 ± 9.0? - education (y) 9.4 ± 4.3? - % male n.r. **HC** (n = 83) - age (y) 73.6 ± 9.8 - education (y) 8.1 ± 4.6 - % male n.r. - MMSE 26.9 ± 1.9? - MMSE 29.5 ± 1.2	**FDM test**[c] (scores on six domains)	- People living with MCI showed significantly lower FDM performances than HC on all domains of the FDM test.	MCI (amnestic)< HC
Giannouli et al. (2018)[+]	Greece	CS	**MCI** (n = 20) / Type: amnestic - age (y) n.r.d - education (y) n.r.d - % male n.r.d **HC** (n = 22) - age (y) n.r.d - education (y) n.r.d - % male n.r.d - MMSE 27.0 ± 2.9? - MMSE 29.2 ± 0.9	**LCPLTAS** (scores on seven domains, total score based on all domains)	- People living with MCI showed a significantly lower FDM performance than HC on the LCPLTAS total score and on all domains separately.	MCI (amnestic) < HC
Griffith et al. (2003)[+]	USA	CS	**MCI** (n = 21) / Type: amnestic - age (y) 68.1 ± 8.8 - education (y) 14.3 ± 2.2 - 47.6% male **HC** (n = 21) - age (y) 66.7 ± 7.2 - education (y) 14.3 ± 2.7 - 33.3% male - MMSE 28.4 ± 1.2 - DRS 129.2 ± 5.7* - CDR 0.0 or 0.5* - MMSE 29.3 ± 1.0 - DRS 137.4 ± 4.3 - CDR 0.0 or 0.5	**FCI** (scores on domains 1-9, total score based on domains 1-7)	- People living with MCI showed significantly lower FDM performances than HC on the total score and on the domains 'financial concepts', 'bank statement management' and 'bill payment'. No differences were found with regard to the other domains.	MCI (amnestic) ≤ HC
Griffith et al. (2010)	USA	CS	**MCI** (n = 38) / Type: amnestic - age (y) 70.8 ± 6.4 - education 14.2 ± 2.6 - 34.2% male **HC** (n = 28) - age (y) 71.6 ± 5.4 - MMSE 28.2 ± 1.4* - MMSE 29.4 ± 1.1	**FCI** (total score based on domain 2, 5-7)	- People living with MCI showed a significantly lower FDM performance than HC on the FCI total score.	MCI (amnestic) < HC

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Table 2b (*continued*)

Study	Country	Design	Sample characteristics	FDM task (scale)	Main outcome	Conclusion
Kenney et al. (2019)	USA	CS	- education 14.8 ± 2.6 - 32.1% male **MCI** (n = 160) / Type: n.r. - age (y) n.r. - education n.r. - n.r. - % male n.r. **HC** (n = 71) - age (y) n.r. - education n.r. - n.r. - % male n.r.	**Subtest 'Bill Payment' of the NAB** (total score)	People living with MCI showed significantly lower FDM performances than HC on the NAB 'Bill Payment' total score.	MCI < HC
Lassen-Greene et al. (2017)	USA	CS + LS	**MCI** (n = 80) / Type: n.r. - age (y) 70.6 ± 7.6 - education 15.2 ± 3.0 - DRS 132.3 ± 6.9* - 53.8% male* **HC** (n = 80) - age (y) 68.6 ± 7.5 - education 15.2 ± 2.5 - DRS 138.6 ± 5.5 - 36.3% male	**FCI** (total score based on domain 2, 3, 5, 7)	- At baseline, people living with MCI showed a significantly lower FDM performance than HC on the FCI total score. - People living with MCI showed significant deterioration over time (in total 5 visits over a three-year period). No significant deterioration was observed in HC.	MCI < HC
Lui et al. (2013)[+]	China[++]	CS	**MCI** (n = 92) / Type: amnestic - age (y) 77.8 ± 6.8* - education (y) 3.0 ± 3.2* - MMSE 25.3 ± 2.6* - 28.3% male* **HC** (n = 93) - age (y) 74.2 ± 6.5 - education (y) 4.3 ± 3.7 - MMSE 26.6 ± 2.5 - 10.8% male	**'money management' version of ACED** – Chinese version (scores on four domains, total score based on all four domains)	- People living with MCI showed significantly lower FDM performances than HC on the 'money management' total score and on all domains separately, with the exception of 'expressing a choice'.	MCI (amnestic) ≤HC
Marson et al. (2009)[+]	USA	CS	**MCI** (n = 58) / Type: amnestic - age (y) 68.0 ± 8.3* - MMSE 28.2 ± 1.9 - education (y) 13.7 ± 2.0* - DRS 131.3 ± 7.4* - 31.0% male* - CDR 0.0 to 1.0 **HC** (n = 75) - age (y) 66.1 ± 7.7 - MMSE 29.3 ± 1.0 - education (y) 14.3 ± 1.6 - DRS 138.7 ± 3.8 - 32.0% male - CDR 0.0 or 0.5	**SCIFC** (scores on domains 1-8, total score based on domains 1-7)	- People living with MCI showed significantly lower FDM performances than HC on the SCIFC total score and on 'bank statement management', but not on other domains.	MCI (amnestic) ≤ HC
Martin et al. (2019)[+]	USA	CS + LS	**MCI** (n = 91) / Type: n.r. - age (y) 72.1 ± 6.4* - MMSE 27.6 ± 1.9* - education (y) 14.7 ± 3.1 - DRS 130.6 ± 6.7* - 54.9% male - CDR 0.0 to 0.5 **HC** (n = 82) - age (y) 66.3 ± 8.5 - MMSE 29.5 ± 0.9 - DRS 138.9 ± 3.7	**FCI** (scores on domains 1-9, total score based on domains 1-7, total score based on domains 1-7, 9)	- People living with MCI showed significantly lower FDM performances than HC on the FCI total scores and on all domains separately, with the exception of 'knowledge of personal finances'. - After 6-years follow-up, people living with MCI showed a significant deterioration on the FCI total scores and on all domains separately. No significant deterioration was observed in HC.	MCI ≤ HC

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Table 2b (*continued*)

Study	Country	Design	Sample characteristics	FDM task (scale)	Main outcome	Conclusion
Niccolai et al. (2017)	USA	LS	- education (y) 15.2 ± 2.5 - 36.6% male - CDR 0.0 or 0.5 **MCI** (n = 48) / Type: amnestic - age (y) 71.4 ± 6.4* - education 14.7 ± 3.3 - 54.2% male - MMSE 27.6 ± 1.9* - DRS 131.1 ± 7.4* **HC** (n = 66) - age (y) 66.3 ± 8.6 - education 15.1 ± 2.4 - 36.4% male - MMSE 29.6 ± 0.8 - DRS 139.0 ± 3.3	**FCI** (total score based on domains 1-7)	- After 2-year follow-up, people living with MCI showed a significant deterioration on the FCI total score compared to baseline. No significant deterioration was observed in HC. - The FCI total score at baseline was not significantly correlated with the change score of the FCI total score.	N/A
Okonkwo et al. (2006)	USA	CS	**MCI** (n = 43) / Type: amnestic/non-amnestic - age (y) 69.5 ± 8.2 - education 14.7 ± 3.0 - 55.8% male - MMSE 28.5 ± 1.5* - DRS 132.9 ± 6.9* **HC** (n = 43) - age (y) 66.8 ± 7.4 - education 15.1 ± 2.5 - 37.2% male - MMSE 29.4 ± 0.9 - DRS 138.3 ± 6.5	**FCI** (scores on domains 2, 3, 5, 7)	- People living with MCI showed significantly lower FDM performances than HC on all FCI domains, with the exception of 'cash transactions'.	MCI (amnestic/non-amnestic) ≤ HC
Okonkwo et al. (2009)	USA	CS	**MCI** (n = 57) / Type: amnestic - age (y) 70.1 ± 8.1 - education 15.4 ± 3.0 - 52.6% male - DRS 133.0 ± 7.9* - GDS 4.5 ± 4.4 **HC** (n = 68) - age (y) 67.9 ± 7.4 - education 15.1 ± 2.5 - 38.2% male - DRS 139.4 ± 3.9 - GDS 4.0 ± 5.2	**FCI** (total score based on domain 2, 3, 5, 7)	- Significantly more people living with MCI (39.3%) showed some difficulty (≤ 1.5SD below the mean of controls) with FDM on the FCI total score than HC (6.2%).	MCI (amnestic) ≤ HC
Pereira et al. (2010b)[+]	Brazil	CS + LS	**MCI** (n = 31) / Type: amnestic / non-amnestic - age (y) 72.9 ± 7.0 - education (y) 8.5 ± 5.5* - 26.0% male? - MMSE 27.3 ± 2.3 **HC** (n = 32) - age (y) 71.6 ± 5.6 - education (y) 13.3 ± 6.0 - 25.0% male - MMSE 28.8 ± 1.5	**Subscale 'financial skills' of DAFS** – Brazilian version (total score)	- People living with MCI showed a significantly lower FDM performance than HC on the total score of the 'financial skills' subscale. - No significant differences were found between MCI subtypes and between MCI converters (n = 8, follow-up at 15.7 ± 3.7 months) and non-converters (n = 23, follow-up at 17.1 ± 4.1 months). - FDM (total score of the 'financial skills' subscale) was moderately negatively correlated with total tau and phospho-Ttau$_{181}$ concentrations in cerebrospinal fluid in people living with MCI.	MCI (amnestic/non-amnestic) < HC MCI (amnestic) = MCI (non-amnestic) MCI (converters) = MCI (non-converters)
Sherod et al. (2009)[+]	USA	CS	**MCI** (n = 113) / Type: amnestic - age (y) 70.3 ± 7.4* - MMSE 28.1 ± 1.9* - DRS 130.9 ± 6.4* - CDR 0 or 0.5*	**FCI** (total score based on domains 1-7)	- People living with MCI showed a significantly lower FDM performance than HC on the FCI total score.	MCI (amnestic) < HC

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Table 2b (*continued*)

Study	Country	Design	Sample characteristics	FDM task (scale)	Main outcome	Conclusion
Tolbert et al. (2019)+	USA	CS	**HC** (n = 85) - age (y) 67.2 ± 8.2 - education (y) 15.0 ± 2.4 - 35.3% male - MMSE 29.4 ± 0.9 - DRS 138.8 ± 3.3 - CDR 0 or 0.5 **MCI** (n = 79) / Type: amnestic - age (y) 71.4 ± 6.7 - education (y) 16.3 ± 2.8 - 57.0% male - MMSE 27.8 ± 2.4* - CDR 0 or 0.5? **HC** (n = 144) - age (y) 71.6 ± 6.2 - education (y) 16.8 ± 2.4 - 48.0% male - MMSE 29.1 ± 1.0 - CDR 0 **MCI converters** (n = 25) / Type: n.r. - age (y) 74.4 ± 6.0§ - education (y) 14.4 ± 3.3 - 44.0% male - MMSE 27.0 ± 1.9§* - DRS 127.4 ± 5.8§* - CDR 0.5*	**FCI – SF** (score on 5 domains and total score based on all domains)	- People living with MCI showed a significantly lower FDM performance than HC on the FCI – SF total score and on all domains separately, with the exception of 'mental calculation'.	MCI (amnestic) ≤ HC
Triebel et al. (2009)	USA	LS	**MCI non-converters** (n = 62) / Type: n.r. - age (y) 68.5 ± 7.5 - education (y) 15.2 ± 2.8 - 45.2% male - MMSE 28.6 ± 1.4* - DRS 134.2 ± 5.9* - CDR 0.5* **HC** (n = 76) - age (y) 66.7 ± 8.5 - education (y) 15.0 ± 2.3 - 36.8% male - MMSE 29.4 ± 1.0 - DRS 138.6 ± 3.4 - CDR 0	**FCI** (scores on domains 1-7, 9, total score based on domains 1-7, total score based on domains 1-7, 9)	- After 1-year follow-up, MCI converters showed significantly steeper deteriorations than HC and MCI non-converters on the FCI total scores and domain 'checkbook management'. No significant deterioration was observed in HC and MCI non-converters.	N/A

Note. All results are considered significant when $p < .05$.
ACED = Assessment of Capacity for Everyday Decision-making; **CS** = Cross-Sectional study; **CDR** = Clinical Dementia Rating; **DMCAT** = Decision Making Competence Assessment Tool; **DRS** = Dementia Rating Scale; **DAFS** = Direct Assessment of Functional Status; **FCI** = Financial Capacity Instrument; **FCI-SF** = Financial Capacity Instrument -Short Form; **FDM** = Financial Decision-Making; **GDS** = Global Deterioration Scale; **HC** = Healthy controls; **ILS** = Independent Living Scale; **LCPLTAS** = Legal Capacity for Property Law Transactions Assessment Scale; **LS** = Longitudinal Study; **MCI** = Mild Cognitive Impairment; **MMSE** = Mini-Mental State Examination; **n.r.** = not reported; **N/A** = not applicable; **NAB** = Neuropsychological Assessment Battery; **NADL** = Numerical Activities of Daily Living; **NADL-F** = Numerical Activities of Daily Living – Financial; **SCIFC** = Semi-Structured Clinical Interview for Financial Capacity; **UMCFAB** = University of Miami Computer-Based Functional Assessment Battery.
a Participants were matched based on age and level of education.
b Global cognition = average z-score based on nineteen measures of cognition.
c No official name of test reported, test is likely a pilot version of the LCPLTAS.
d Participants were matched based on sex, level of education and age.
+ Study included more than one NDD group.
++ In collaboration with authors from other countries.
* Significant difference between people living with MCI and HC.
§ Significant difference with other NDD group(s).
? Group differences not analyzed/reported.
< Performances significantly worse on all FDM outcome measures.
≤ Performances significantly worse on some FDM outcome measures, but not all.
= Performances are equal on all FDM outcome measures.

Table 2c
Overview of studies measuring financial decision-making in people living with frontotemporal dementia (k = 3)

Study	Country	Design	Sample characteristics	FDM task (scale)	Main outcome	Conclusion
Giannouli et al. (2018)+	Italy	CS	**FTD** (n = 17) / Type: n.r. - age (y) n.r.a - education (y) n.r.a - % male n.r.a - MMSE 16.8 ± 6.0? **HC** (n = 22) - age (y) n.r.a - education (y) n.r.a - % male n.r.a - MMSE 29.2 ± 0.9	**LCPLTAS** (scores on seven domains, total score based on all domains)	- People living with FTD showed a significantly lower FDM performance than HC on the LCPLTAS total score and on all domains separately.	FTD < HC
Gill et al. (2019)+	Canada++	CS	**FTD** (n = 15) / Type: behavioral variant - age (y) 67.5 ± 8.7 - education (y) 13.9 ± 2.7 - 46.7% male? - MoCa 19.1 ± 4.7* **HC** (n = 20) - age (y) 67.9 ± 8.9 - education (y) 13.7 ± 2.9 - 40.0% male - MoCa 27.3 ± 1.9	**FACT** (scores on eight domains and total score based on all domains) & **FCAI** (scores on six domains, total score based on all domains)	- People living with FTD showed a significantly lower FDM performance than HC on the FACT total score and on all domains separately, with the exception of 'reading/writing' and 'rational beliefs about money'. - People living with FTD showed a significantly lower FDM performance than HC on the FCAI total score and all domains separately, with the exception of 'debt management'.	FTD ≤ HC
Lima-Silva et al. (2015)+	Brazil	CS	**FTD** (n = 20) / Type: behavioral variant - age (y) 67.1 ± 6.6 - education (y) 9.6 ± 5.9 - 70.0% male - MMSE 23.5 ± 4.3 - CDR 1.0 **HC** (n = 34) - age (y) 65.4 ± 5.9 - education (y) 9.6 ± 3.9 - 62.8% male - MMSE 25.5 ± 1.3 - CDR n.r.	**Subscale 'financial skills' of DAFS** – Brazilian version (total score)	People living with FTD showed a significantly lower FDM performance than HC on the 'financial skills' total score.	FTD < HC

Note. All results are considered significant when $p < .05$.
CDR = Clinical Dementia Rating; **CS** = Cross-Sectional study; **DAFS** = Direct Assessment of Functional Performance; **FACT** = Financial Assessment and Capacity Test; **FCAI** = Financial Competence Assessment Inventory; **FDM** = financial decision-making; **FTD** = frontotemporal dementia; **HC** = healthy controls; **LCPLTAS** = Legal Capacity for Property Law Transactions Assessment Scale; **MMSE** = Mini-Mental State Examination; **MoCa** = Montreal Cognitive Assessment; **n.r.** = not reported.
a Participants were matched based on sex, level of education and age.
+ Study included more than one NDD group.
++ In collaboration with authors from other countries.
* Significant difference between people living with FTD and HC.
? Group differences not analyzed/reported.
< Performances significantly worse on all FDM outcome measures.
≤ Performances significantly worse on some FDM outcome measures, but not all.

lower in people living with mild AD compared to healthy controls in all studies that included people living with mild AD. Four studies (Giannouli et al., 2018; Giannouli and Tsolaki, 2014; Marson et al., 2009, 2000) divided the included participants in multiple subgroups based on disease severity which enabled the comparison of people living with AD in different disease stages. These studies indicate that when the disease progresses to more moderate or severe stages, people living with AD show difficulties with all aspects of FDM compared to healthy controls and performed significantly worse on FDM tests than people living with mild AD.

3.1.1. *Longitudinal studies*

Significant deterioration of FDM over a one-year period was observed in people living with AD in three independent follow-up studies (Clark et al., 2014; Loewenstein et al., 1995; Martin et al., 2008). Decline was found for all domains of FDM, measured with the DAFS (Loewenstein et al., 1995) and the FCI (Clark et al., 2014; Martin et al., 2008), with the exception of 'knowledge about assets and estate' (experimental domain of the FCI; Martin et al., 2008). Although the differences between baseline and follow-up were significant in all studies, the clinical relevance of the observed decline is unclear, since the differences in scores after a one-year period were sometimes less than one point on subscales with scoring ranges from 0 – 3 or 0 – 8, depending on the subscale (Loewenstein et al., 1995). Clark and colleagues (2014) defined significant decline as a drop of more than 10 points on the FCI compared to a previous assessment. According to this definition, at a follow-up of one-year, almost half of the people living with AD (45.5%) that were included in the study showed a significant decline on the FCI compared to baseline; after two-year follow-up an additional 20% of participants showed decline compared to the assessment at one-year follow-up. It has to be taken into account, however, that only eleven and five participants, respectively, were assessed after the one-year and two-year follow-up.

3.1.2. *The association between FDM and cognition in people living with AD*

A summary of the cognitive functions that were evaluated in relation to FDM can be found in Table 3. Significant moderate to strong positive correlations between FDM performances and global cognition, as measured with, e.g., the Mini-Mental State Examination or Dementia Rating Scale, are found in people living with AD (Griffith et al., 2007;

Table 2d
Overview of studies measuring financial decision-making in people living with Parkinson's disease (k = 6)[a]

Study	Country	Design	Sample characteristics	FDM task (scale)	Main outcome	Conclusion
Giannouli & Tsolaki (2014)+	Italy	CS	**PD** (n = 10) - age (y) 75.6 ± 10.0? - education (y) 8.5 ± 5.2? - % male n.r. - MMSE 24.3 ± 4.8? - UPDRS n.r. - H&Y n.r. **HC** (n = 83) - age (y) 73.6 ± 9.8 - education (y) 8.1 ± 4.6 - % male n.r. - MMSE 29.5 ± 1.2	**FDM test**[b] (scores on six domains)	- People living with PD showed significantly lower FDM performances than HC on all domains of the FDM test.	PD < HC
Giannouli et al. (2018)+	Italy	CS	**PD with dementia** (n = 17) - age (y) n.r.c - education (y) n.r.c - % male n.r.c - MMSE 21.6 ± 4.5? - UPDRS n.r. - H&Y n.r. **HC** (n = 22) - age (y) n.r.c - education (y) n.r.c - % male n.r.c - MMSE 29.2 ± 0.9	**LCPLTAS** (scores on seven domains, total score based on all domains)	- People living with PDD showed a significantly lower FDM performance than HC on the LCPLTAS total score and on all domains separately.	PDD < HC
Giannouli & Tsolaki (2019)	Italy	CS	**PD with dementia without depression** (n = 16) - age (y) 77.2 ± 7.4 - education (y) 8.1 ± 93.6 - % male n.r.c - MMSE 24.8 ± 1.8? - UPDRS n.r. - H&Y n.r. **PD with dementia and depression** (n = 14) - age (y) 74.7 ± 10.4 - education (y) 9.2 ± 4.9 - % male n.r.c - MMSE 19.9 ± 3.3? - UPDRS n.r. - H&Y n.r. **HC without depression** (n = 16) - age (y) 77.1 ± 7.5 - education (y) 8.2 ± 3.4 - % male n.r.c - MMSE 29.6 ± 0.6 **HC with depression** (n = 14) - age (y) 74.8 ± 10.1 - education (y) 8.9 ± 4.3 - % male n.r.c - MMSE 29.4 ± 0.6?	**LCPLTAS** (total score based seven domains)	- People living with PDD with and without depression showed a significantly lower FDM performance than HC with and without depression on the LCPLTAS total score. - People living with PDD with depression showed a significantly lower FDM performance than people living with PDD without depression on the LCPLTAS total score.	PDD < HC
Martin et al. (2013)	USA	CS	**PD with dementia** (n = 17) - age (y) 71.0 ± 6.1 - education (y) 15.1 ± 3.3 - 76.5% male - DRS 116.8 ± 14.1* - CDR 0.5 to 1.0*§ - UPDRS-10 11.9 ± 3.9§ - H&Y n.r. **PD with MCI** (n = 18) - age (y) 66.9 ± 9.3 - education (y) 14.7 ± 2.5 - 50.0% male - DRS 134.7 ± 5.1 - CDR 0.5* - UPDRS-10 8.2 ± 3.9 - H&Y n.r. **HC** (n = 20) - age (y) 69.5 ± 8.1 - education (y) 15.2 ± 2.7 - 50.0% male - DRS 139.5 ± 3.0 - CDR 0	**FCI** (scores on domains 1-9, total score based on domains 1-7 and total score based on domains 1-7, 9)	- People living with PD-MCI showed significantly lower FDM performances than HC on the FCI total score and on the domains 'basic monetary skills', 'financial concepts' and 'investment decisions'. No significant differences were found between people living with PD-MCI and HC regarding all other domains. - People living with PDD showed significantly lower FDM performances than HC and people living with PD-MCI on the FCI total score and on all domains separately, with the exception of 'financial judgment' and 'knowledge of assets/estate arrangement'.	PDD ≤ PD-MCI ≤ HC
Pirogovsky et al. (2012)	USA	CS	**PD** (n = 33) - age (y) 71.2 ± 1.4 - education (y) 16.6 ± 0.4 - DRS 137.3 ± 1.2* - UPDRS n.r.	**AFT** (total score)	People living with PD showed significantly lower FDM performances than HC on the AFT total score. Group differences remained significant after exclusion of people living with PDD (n = 7).	PD < HC

(*continued on next page*)

Table 2d (*continued*)

Study	Country	Design	Sample characteristics	FDM task (scale)	Main outcome	Conclusion
Pirogovsky et al. (2013, 2014)[a]	USA	CS	- 72.7% male - H&Y (median) 2.5 **HC** (n = 26) - age (y) 69.8 ± 1.3 - DRS 140.6 ± 0.5 - education (y) 16.4 ± 0.5 - 65.4% male **PD with MCI** (n = 41) - age (y) 69.2 ± 7.1 - DRS 136.7 ± 4.0** - education (y) 15.8 ± 2.8** - UPDRS 23.1 ± 12.3 - 73.2% male - H&Y (median) 2 **PD cognitively unaffected** (n = 56) - age (y) 66.7 ± 7.5 - DRS 140.1 ± 2.9 - education (y) 17.1 ± 2.4 - UPDRS 25.6 ± 12.3 - 58.9% male - H&Y (median) 2 **HC** (n = 47) - age (y) 67.1 ± 8.7 - DRS 140.4 ± 3.6 - education (y) 16.4 ± 2.5 - 46.8% male	**Subscale 'finances' of the UCSD performance-based skills assessment** (total score)	- When combining both PD groups, people living with PD showed significantly lower FDM performances than HC on the total score of the 'finances' subscale. - People living with PD-MCI showed significantly lower FDM performances than HC on the total score of the 'finances' subscale. No differences in FDM were found between people living with PD-MCI and people living with PD who were cognitively unaffected and between people living with PD who were cognitively unaffected and HC.	PD < HC PD-MCI < HC PD cognitively unaffected = PD-MCI and HC

Note. All results are considered significant when $p < .05$.
AFT = Advanced Finances Test; **CDR** = Clinical Dementia Rating; **CS** = Cross-Sectional study; **DRS** = Dementia Rating Scale; **FCI** = Financial Capacity Instrument; **FDM** = Financial Decision-Making; **H&Y** = Hoehn and Yahr stage; **HC** = Healthy controls; **LCPLTAS** = Legal Capacity for Property Law Transactions Assessment Scale; **MCI** = Mild Cognitive Impairment; **MMSE** = Mini-Mental State Examination; **n.r.** = not reported; **PD** = Parkinson's disease; **PDD** = Parkinson's disease dementia; **PD-MCI** = Parkinson's disease with mild cognitive impairment; **UCSD** = University of California, San Diego; **UPDRS** = Unified Parkinson's Disease Rating Scale.
a Two studies used the same sample and are therefore considered and described as one study.
b No official name of test reported, test is likely a pilot version of the LCPLTAS.
c Participants were matched based on sex, level of education and age.
+ Study included more than one NDD group.
* Significant difference between people living with PD and HC.
§ Significant difference with other NDD group(s).
? Group differences not analyzed/reported.
< Performances significantly worse on all FDM outcome measures.
≤ Performances significantly worse on some FDM outcome measures, but not all.
= Performances are equal on all FDM outcome measures

Table 2e
Overview of studies measuring financial decision-making in people living with multiple sclerosis (k = 3)

Study	Country	Design	Sample characteristics	FDM task (scale)	Main outcome	Conclusion
Gerstenecker et al. (2017b)	USA	CS	**MS** (n = 22) / Type: primary progressive and secondary progressive - age (y) 49.4 ± 8.7 - Global cognition n.r. - education (y) 13.6 ± 2.5 - Onset MS (y) ≥ 5 - 40.9% male - EDSS 5.9 ± 1.0 **HC** (n = 18) - age (y) 48.6 ± 8.8 - education (y) 13.8 ± 2.0 - Global cognition n.r. - 33.3% male	**FCI** (scores on domains 1-7, 9, total score based on domains 1-7, 9)	- People living with MS showed a significantly lower FDM performance than HC on the FCI total score and on all domains separately, with the exception of 'financial judgment' and 'bill payment'. - In people living with MS, 36.4% were classified as severely impaired (degree of impairment ≤ 2.5[a]) and 13.6% were classified as mild/moderately impaired (degree of impairment ≤ 1.5 to > 2.5[a]) based on the FCI total score.	MS ≤ HC
Goverover et al. (2016)	USA	CS	**MS** (n = 30) / Type: relapsing remitting, primary progressive and secondary progressive	**Money management skills assessed with a website-based AR test** (score on five goal-	• People living with MS showed a significantly lower FDM performance than HC on the AR test total score. More specifically, people living with	MS ≤ HC

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Table 2e (*continued*)

Study	Country	Design	Sample characteristics	FDM task (scale)	Main outcome	Conclusion
			- age (y) 47.9 ± 10.6 - education (y) 16.3 ± 2.0 - 23.3% male - Global cognition n.r. - Disease duration (mo) 95.9 ± 53.3 - MSFC (z) -1.3 ± 2.0 **HC** (n = 23) - age (y) 50.0 ± 9.4 - education (y) 16.0 ± 2.3 - 43.5% male - Global cognition n.r. **MS cognitively impaired** (n = 14) / Type: relapsing remitting and uncertain - age (y) 46.8 ± 11.1 - education (y) 14.2 ± 1.9 - 28.6% male - Global cognition n.r. - Disease duration n.r. - TTFW 45.2 ± 73.3 **MS cognitively unaffected** (n = 20) Type: relapsing remitting, secondary progressive, progressive relapsing and uncertain - age (y) 44.3 ± 11.7 - education (y) 15.3 ± 2.5 - 15.0% male - Global cognition n.r. - Disease duration n.r. - TTFW 25.2 ± 54.7 **HC** (n = 16) - age (y) 44.3 ± 13.4 - education (y) 14.2 ± 2.1 - 37.5% male - Global cognition n.r.	directed actions, total score on five goal-directed actions) **FCI** (scores on domains 1-7, 9, total score based on domains 1-7, 9)	MS showed significantly more errors than HC with regard to 'credit card use' and 'performing at an efficient pace' on the AR test. No group differences between people living with MS and HC were found on the other goal-directed actions. - Cognitively impaired people living with MS showed significantly lower FDM performances than HC and cognitively unaffected people living with MS on the FCI total score and on all domains separately, with the exception of 'cash transactions' and 'financial judgment'. - No significant differences were found between cognitively unaffected people living with MS and HC regarding the performances on the FCI.	MS cognitively impaired ≤ MS cognitively unaffected = HC
Tracy et al. (2017)	USA	CS				

Note. All results are considered significant when $p < .05$.
AR test = Actual Reality test; **CS** = Cross-Sectional study; **EDSS** = Expanded Disability Status Score; **FCI** = Financial Capacity Instrument; **FDM** = Financial Decision-Making; **HC** = Healthy controls; **MS** = Multiple Sclerosis; **MSFC** = Multiple Sclerosis Functional Composite score; **n.r.** = not reported; **TTFW** = Timed 25-Foot Walk.
[a] Degree of impairment = (mean_HC – score_person living with MS) / SD_HC.
< Performances significantly worse on all FDM outcome measures.
≤ Performances significantly worse on some FDM outcome measures, but not all.
= Performances are equal on all FDM outcome measures.

Table 2f
Overview of the study measuring financial decision-making in people living with Huntington's disease (k = 1)

Study	Country	Design	Sample characteristics	FDM task (scale)	Main outcome	Conclusion
Sheppard et al. (2017)	USA	CS	**HD** (n = 20) / Stage: symptomatic - age (y) 58.8 ± 12.3 - education (y) 15.2 ± 3.1 - 45.0% male - MDRS 133.7 ± 8.4 - Age of disease onset (y) 50.4 ± 2.8 - UHDRS-TFCS 9.4 ± 0.7 - CAG 42.0 ± 0.6 **HC** (n = 20) - age (y) 61.0 ± 13.7 - education (y) 16.5 ± 2.6 - 40.0% male - MDRS 141.4 ± 2.4	**AFT** (total score)	- People living with HD showed significantly lower FDM performances than HC on the AFT total score.	HD < HC

Note. All results are considered significant when $p < .05$.
AFT = Advanced Finances Test; **CAG** = number of C-A-G repeats; **CS** = Cross-Sectional study; **FDM** = Financial decision-making; **HD** = Huntington's disease; **HC** = Healthy controls; **MDRS** = Mattis Dementia Rating Scale; **UHDRS-TFCS** = Unified Huntington's Disease Rating Scale - Total Functional Capacity Score.
< Performances significantly worse on all FDM outcome measures.

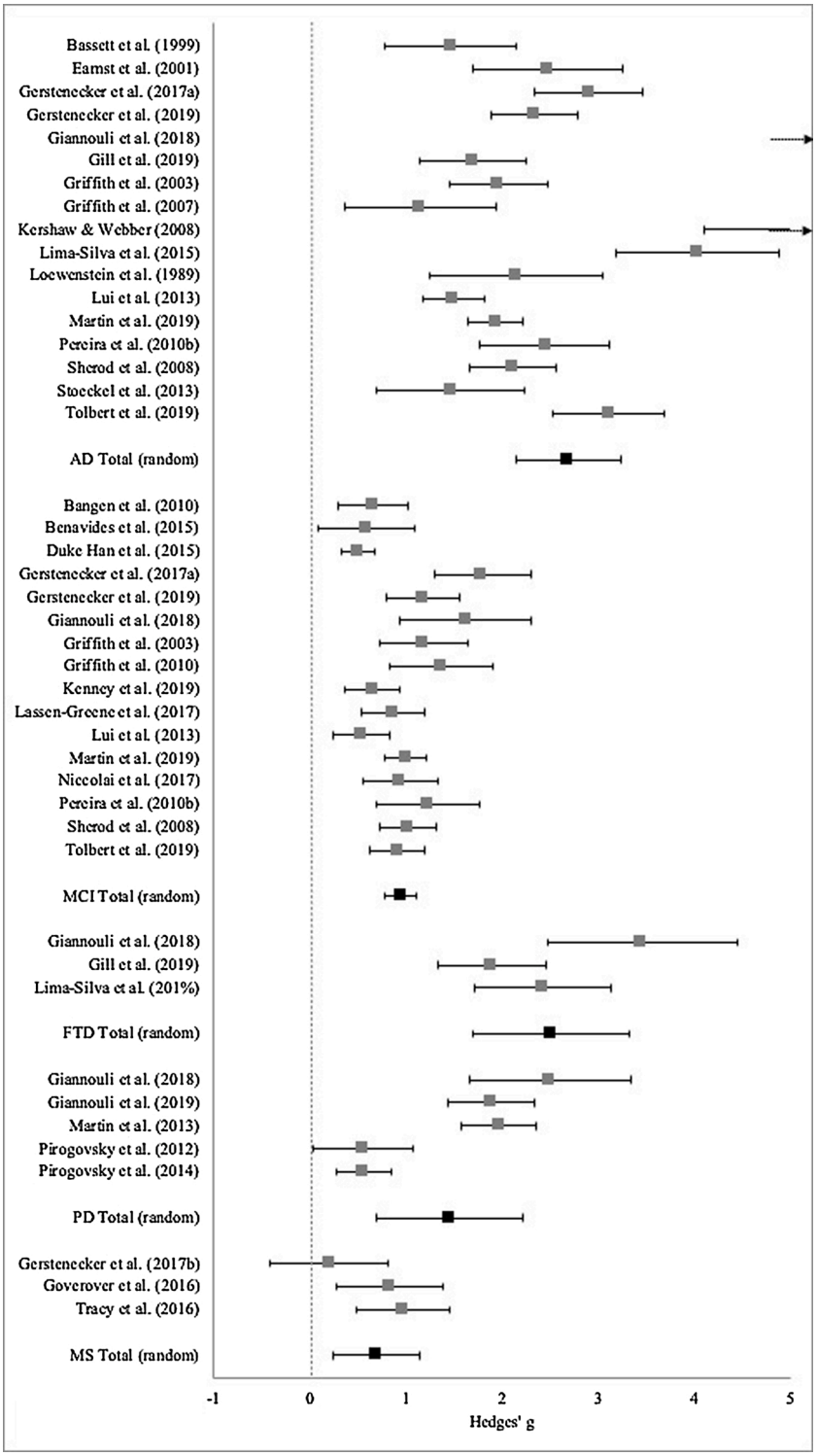

Fig. 2. Forrest plot of studies measuring financial decision-making in people living with Alzheimer's disease (AD), mild cognitive impairment (MCI), frontotemporal dementia (FTD), Parkinson's disease (PD) or multiple sclerosis (MS).

Kershaw and Webber, 2008; Martin et al., 2008; Stoeckel et al., 2013). Two studies, however, did not find significant correlations between financial competence and global cognition (Bassett, 1999; Sherod et al., 2009). When looking at specific cognitive domains, it was found that a slower processing speed was significantly related to lower scores on FDM tests of people living with AD (Bassett, 1999; Sherod et al., 2009). According to Bassett (1999), processing speed even predicted 81.3% of variance of the performance of people living with AD on a FDM test (i.e., FCQ). However, another study that focused on processing speed, as well as on other measures of cognition, found that only 10% of variance of the performances on the FCI of people living with AD could be explained by processing speed (Sherod et al., 2009). In this latter study, 46% of variance was explained by numeracy and 9% of variance of the FCI performance could be explained by verbal short-term memory. Other studies also reported significant correlations between FDM and numeracy (Earnst et al., 2001; Kershaw and Webber, 2008), verbal

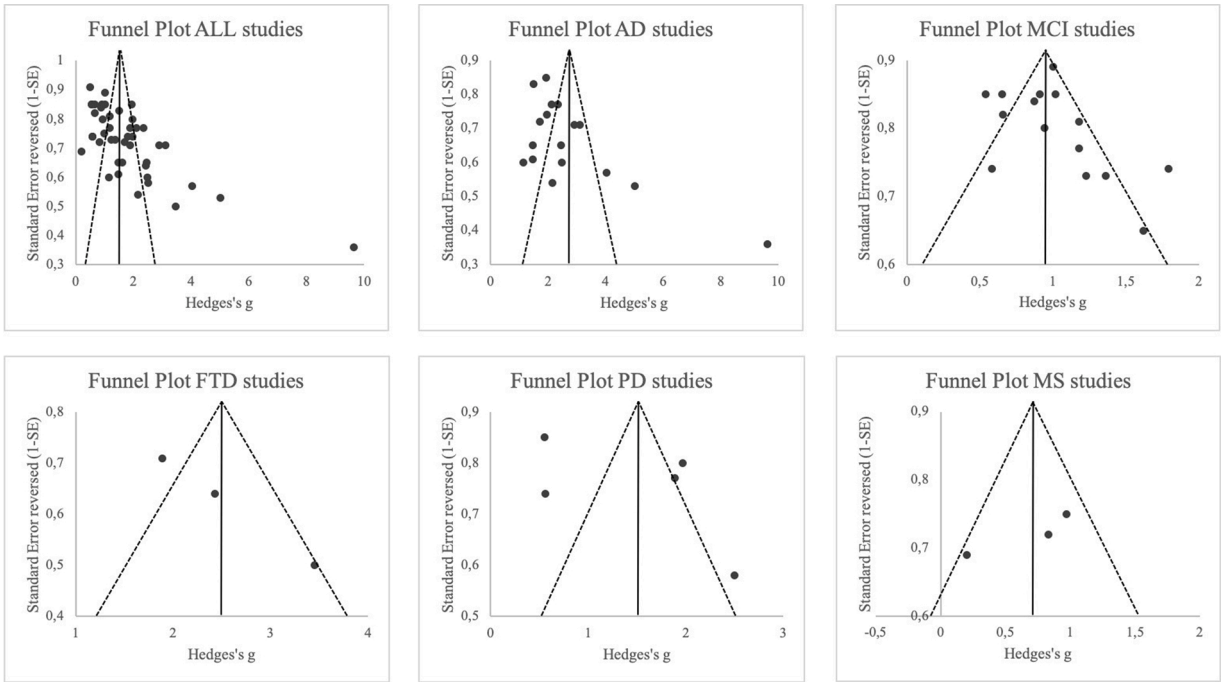

Fig. 3. Funnel plots of studies measuring financial decision-making in people living with Alzheimer's disease (AD), mild cognitive impairment (MCI), frontotemporal dementia (FTD), Parkinson's disease (PD) or multiple sclerosis (MS) included in the meta-analysis. An asymmetric funnel plot indicates publication bias.

memory (Bassett, 1999; Sherod et al., 2009) and working memory (Earnst et al., 2001; Kershaw and Webber, 2008). One study, however, failed to find a significant association between FDM and memory (Stoeckel et al., 2013). Inconclusive results are found with regard to the association between FDM and attention and executive functions (Sherod et al., 2009; Stoeckel et al., 2013) in people living with AD. Furthermore, no significant association was found between visuospatial abilities and FDM in people living with AD (Sherod et al., 2009; Stoeckel et al., 2013).

3.1.3. Influence of age, sex, education and symptoms of depression in people living with AD

In general there are no indications that age has an influence on FDM in people living with AD, since no significant correlations were reported (Bassett, 1999; Mahurin et al., 1991; Martin et al., 2008). Nevertheless, significant differences between people living with AD and people living with FTD on an FDM tests (i.e., FACT total score and FCAI appreciation scale) were no longer significant when controlling for age (Gill et al., 2019), assuming some influence of age. Giannouli et al. (2018) reported that years of education are a better predictor of financial capacity as examined with the LCPLTAS than classic neuropsychological measures and other demographic factors in a dementia sample (i.e., a mixed sample of people living with AD and people living with other types of dementia). The number of years of education was also a significant predictor of performances on seven out of eight FCI domains in people living with AD (Martin et al., 2008). These associations could, however, not be confirmed by two other studies (Bassett, 1999; Mahurin et al., 1991). Sex was found to be a significant predictor of one out of eight FCI domains (Martin et al., 2008). No significant correlations were found between performances on FDM tests and scores on depression questionnaires (Mahurin et al., 1991; Martin et al., 2008).

3.2. Mild Cognitive Impairment(MCI)

Twenty-six studies investigated FDM in people living with MCI. In total, 1727 people living with MCI were included in these studies and the average age of people living with MCI ranged from 68.0 to 84.3 years (weighted average = 72.9 years). In most studies, participants were diagnosed with single- or multiple-domain amnestic MCI (Table 2b). However, not all studies reported the subtype of MCI of the participants that were included (Arcara et al., 2019; Benavides-Varela et al., 2015; Clark et al., 2014; Duke Han et al., 2015; Gerstenecker et al., 2016; Kenney et al., 2019; Lassen-Greene et al., 2017; Martin et al., 2019; Triebel et al., 2009). Some studies used a mixed MCI group including both single- and/or multiple-domain amnestic and non-amnestic MCI (Bangen et al., 2010; Okonkwo et al., 2006; Pereira et al., 2010b) and three studies divided their sample in people living with MCI who progressed to AD and people living with MCI who showed no progression at follow-up (e.g., MCI converters vs. MCI non-converters, respectively; Bangen et al., 2010; Clark et al., 2014; Triebel et al., 2009).

All cross-sectional studies on MCI reported that participants showed significantly lower total scores on tests of FDM compared to healthy controls (Table 2b). Some aspects of FDM appear to remain intact in people living with MCI, although results are mixed. Most consistently, studies reported difficulties with 'financial conceptual knowledge', 'checkbook management', 'bank statement management' and 'bill payment' in people living with MCI compared to healthy controls (Gerstenecker et al., 2016, 2017a, 2019; Giannouli et al., 2018; Griffith et al., 2003; Martin et al., 2019; Okonkwo et al., 2006). The domains 'basic monetary skills' and 'financial judgment' of the FCI seem to remain relatively intact in people living with MCI (Gerstenecker et al., 2019, 2017a, 2016; Griffith et al., 2003). Furthermore, people living with MCI appear to have no difficulties with 'expressing a choice' when making financial decisions (Lui et al., 2013), but need more time than healthy controls to complete a FDM task (Lassen-Greene et al., 2017; Okonkwo et al., 2006). In a computer-based simulation task, people living with MCI were found to have more difficulties than healthy controls with the use of an ATM (Czaja et al., 2017).

As expected, and in accordance with the findings mentioned above, an overall medium to large pooled mean effect size was found in the meta-analysis when comparing the performances of people living with MCI and healthy controls on tests of FDM ($g = 0.95$ [0.78; 1.11], $SE = 0.08$, $p < .001$ based on 16 studies; Fig. 2). Significant heterogeneity was, however, found ($Q(15) = 55.2$, $p < .001$, $I^2 = 72.8\%$). More than half of the studies on MCI used the FCI (n = 9) and for these studies a

Table 3
Associations between FDM and cognition in people living with neurodegenerative diseases. (Bassett 1999; Earnst et al. 2001; Griffith et al. 2007; Kershaw & Webber 2008; Martin et al. 2008; Sherod et al. 2009; Stoeckel et al. 2013; Arcara et al. 2019; Bangen et al. 2010; Benavides-Varela et al. 2015; Czaja et al. 2017; Duke Han et al. 2015; Gerstenecker et al. 2016; Griffith et al. 2010; Niccolai et al. 2017; Niccolai et al. 2017; Okonkwo et al. 2006; Sherod et al. 2009; Clark et al. 2014; Lui et al. 2013; Giannouli & Tsolaki 2014; Giannouli et al. 2018; Giannouli & Tsolaki 2019; Pirogovsky et al. 2012; Pirogovsky et al. 2013;2014; Gerstenecker et al. 2017b;Goverover et al., 2016; Tracy et al. 2017; Sheppard et al. 2017;)

Study	Group	FDM task	Global cognition	Verbal memory	Episodic memory	Prospective memory	Visuospatial memory	Verbal fluency	Processing speed	Attention	Language	Executive functions	Working memory	Cognitive flexibility	Verbal reasoning	Abstract reasoning	Initiation and perseveration	Numeracy	Visuospatial abilities
Bassett 1999	AD	FCQ	n.s.	+					+										
Earnst et al. 2001	AD	FCI											+					+	
Griffith et al. 2007	AD	FCI	+																
Kershaw & Webber 2008	AD	FCAI	+										+			+		+	
Martin et al. 2008	AD	FCI	+																
Sherod et al. 2009*	AD	FCI	n.s.	+				n.s.	+	n.s.		n.s.						+	n.s.
Stoeckel et al. 2013	AD	FCI	+	n.s.						+		+							n.s.
Arcara et al. 2019	MCI[†a]	NADL-F	+	+				+					+						
Bangen et al. 2010	MCI[†]	ILS	+	n.s.								n.s.							
Benavides-Varela et al. 2015*	MCI	NADL		n.s.						n.s.	n.s.	n.s.				+			+
Czaja et al. 2017	MCI	UMCFAB		n.s.				n.s.	+					+		n.s.			n.s.
Duke Han et al. 2015*	MCI	DMCAT	+	+	n.s.				+				+						n.s.
Gerstenecker et al. 2016	MCI	FCI	+																
Griffith et al. 2010	MCI	FCI							+	+								+	
Niccolai et al. 2017	MCI	FCI		n.s.			+	+	+	n.s.	+	n.s.						+	
Niccolai et al. 2017*	MCI	FCI		n.s.			+	n.s.	+	n.s.	n.s.	n.s.						+	
Okonkwo et al. 2006*	MCI	FCI		n.s.						+	n.s.	+							n.s.
Sherod et al. 2009*	MCI	FCI	n.s.	n.s.				n.s.	n.s.	n.s.		+						+	n.s.
Clark et al. 2014	mixed[b]	FCI	+	+	n.s.					n.s.	+	n.s.	+				+		
Lui et al. 2013	mixed[b]	ACED	+	n.s.				+											
Giannouli & Tsolaki 2014*	mixed[d]	FDM test[c]	+																
Giannouli et al. 2018*	mixed[e]	LCPLTAS	+	n.s.			n.s.	n.s.		n.s.		+	+						
Giannouli & Tsolaki 2019	PD[†]	LCPLTAS	+																
Pirogovsky et al. 2012	PD	AFT	+			+													
Pirogovsky et al. 2013/2014[f]	PD	UCSD-PBSA	n.s.	n.s.			n.s.			n.s.	n.s.	n.s.							n.s.
Gerstenecker et al. 2017b	MS[†]	FCI		+			+		+	+	+	+						+	
Goreover et al. 2016	MS[†]	AR test		+		n.s.	+		+			+	+						
Tracy et al. 2017*	MS[†]	FCI											+	+	+				
Sheppard et al. 2017	HD	AFT	+																
SUMMARY (k significant / k number of studies)			15/19	7/18	0/2	1/2	4/6	3/8	10/11	4/12	3/7	6/13	8/8	2/2	1/1	2/3	1/1	8/8	1/8
SUMMARY (% significant)			84.2	38. 9	0.0	50.0	66.7	37.5	90.9	33.3	42.9	46.2	100.0	100.0	100.0	66.7	100.0	100.0	12.5

Note. All correlations are in the expected direction (e.g., poorer performances on a test of cognition are associated with poorer performances on test of FDM). Empty gray cell means that cognitive domains were not evaluated. **AD** = Alzheimer's disease; **ACED** = Assessment of Capacity for Everyday Decision-making; **AFT** = Advanced Finances Test; **AR test** = Actual Reality test; **DMCAT** = Decision-Making Competence Assessment Tool; **FCAI** = Financial Competence Assessment Inventory; **FCI** = Financial Capacity Instrument; **FCQ** = Financial Competency Questions; **HD** = Huntington's disease; **ILS** = Independent Living Scale; **LCPLTAS** = Legal Capacity for Prospective and Retrospective Memory Questionnaire; **MCI** = mild cognitive impairment; **MS** = multiple sclerosis; **NADL** = Numerical Activities of Daily Living; **NADL-F** = Numerical Activities of Daily Living - Financial; **PD** = Parkinson's disease; **UCSD-PBSA** = University of California, San Diego - Performance-Based Skills Assessment; **UMCFAB** = University of Miami Computer-Based Functional Assessment Battery.
a Includes also 5 people living with pathologies other than MCI.
b Mixed group including people living with AD, people living with MCI and healthy controls.
c No official name of test reported, test is likely a pilot version of the LCPLTAS.
d Mixed group including people living with AD, people living with MCI, people living with PD and healthy controls.
e Mixed group including people living with AD, people living with MCI, people living with PD, people living with FTD, people living with vascular dementia and healthy controls.
f Studies presumably used the same sample and are therefore considered and described as one study.
† Included both people with an NDD and healthy controls in analyses.
* (multiple) regression analyses used instead of correlation analyses.
+ Means significant correlation/predictor.
n.s. Means not significant correlation/predictor.

significantly larger pooled mean effect size was found ($g = 1.09$ [0.92; 1.25], $SE = 0.09$, $p < .001$; $Q(1) = 8.80$, $p = .003$) compared to the seven studies using FDM tests other than the FCI ($g = 0.70$ [0.52; 0.89], $SE = 0.10$, $p < .001$). The funnel plot showed a significant asymmetry ($p = .005$; Fig. 3).

One study (Bangen et al., 2010) compared people living with amnestic MCI, people living with non-amnestic MCI and healthy controls and only found significant differences between people living with amnestic MCI and healthy controls, while other group comparisons were not significant. These findings are consistent with another study comparing people living with different subtypes of MCI (Pereira et al., 2010b). Interestingly, based on binary logistic regression, the 'money management' subscale of the ILS was a significant contributor in the prediction of the subtype of MCI (i.e., amnestic or non-amnestic MCI; Bangen et al., 2010).

3.2.1. *Longitudinal studies*

Over time, people living with MCI showed a significant deterioration on multiple domains of FDM (Clark et al., 2014; Gerstenecker et al., 2016; Lassen-Greene et al., 2017; Martin et al., 2019; Niccolai et al., 2017; Pereira et al., 2010b; Triebel et al., 2009). In one study (Triebel et al., 2009), after a one-year follow-up, 18% of participants converted from MCI to AD and showed a stronger deterioration than MCI non-converters on overall FDM (i.e., total score) and, more specifically, on 'checkbook management' of the FCI. Furthermore, deterioration was found in people living with MCI after two-years for 'checkbook management', 'bank statement management', 'bill payment' and 'investment decision making' of the FCI (Gerstenecker et al., 2016). Two other

studies also reported significant deterioration after two-years in FDM performances in people living with MCI (Clark et al., 2014; Niccolai et al., 2017). Clark et al. (2014) demonstrated that MCI converters showed more often a significant decline on the FCI (i.e., a decline of more than 10 points) after one as well as after two-year(s) follow-up compared to MCI non-converters. However, statistics for group comparisons were not reported. MCI converters may already have more difficulties with some aspects of FDM at baseline compared to MCI non-converters (Triebel et al., 2009), however, two other studies did not support this finding (Clark et al., 2014; Pereira et al., 2010b). Furthermore, baseline performances of people living with MCI could not predict the deterioration after two years (Niccolai et al., 2017). Lassen-Greene et al. (2017) explored the performances on the FCI in more detail and reported that in people living with MCI only the accuracy of performances, not the speed of processing, deteriorates over a three-years period. Finally, Martin et al. (2019) performed a three and six-years follow-up using the FCI. Comparing the performances at baseline, three-years follow-up and six-years follow-up, they found a significant deterioration over time on the FCI total score and on all domains separately in people living with MCI, while no deterioration was observed in healthy controls.

3.2.2. The association between FDM and cognition in people living with MCI

Also in people living with MCI, a decreased performance on tests of global cognition was found to be associated with decreased performances on tests of FDM (Arcara et al., 2019; Bangen et al., 2010; Duke Han et al., 2015; Gerstenecker et al., 2016; Table 3). General cognition, defined as the average of performances on nineteen tests of cognition, predicted 14% of variance of performance on an FDM test (Duke Han et al., 2015). When exploring different aspects of cognition in more detail, it appears that especially processing speed is related to FDM in people living with MCI since mild to strong correlations were found between measures of processing speed and FDM (Czaja et al., 2017; Duke Han et al., 2015; Griffith et al., 2010; Niccolai et al., 2017). Also numeracy was found to be significantly related to FDM in people living with MCI (Griffith et al., 2010; Niccolai et al., 2017; Sherod et al., 2009), explaining 37.6 to 55.0% of variance of performances on tests of FDM (Niccolai et al., 2017; Sherod et al., 2009). Furthermore, significant correlations were found between FDM and attention (Griffith et al., 2010; Okonkwo et al., 2006), visuospatial memory (Niccolai et al., 2017), visuomotor abilities (Benavides-Varela et al., 2015), language (Niccolai et al., 2017) and executive functions (Okonkwo et al., 2006; Sherod et al., 2009; more specifically working memory (Duke Han et al., 2015), cognitive flexibility (Czaja et al., 2017) and abstract reasoning (Benavides-Varela et al., 2015)) in people living with MCI, although results are mixed.

3.2.3. Influence of age, sex, education and symptoms of depression in people living with MCI

Some studies found evidence that a higher age was associated with lower performances on FDM tests in people living with MCI (Duke Han et al., 2015; Lassen-Greene et al., 2017; Lui et al., 2013; Tolbert et al., 2019). Age can, however, not fully explain the differences that were found between people living with MCI and healthy controls regarding FDM since some studies controlled for age in their group analyses and still found significant differences between groups on tests of FDM (Arcara et al., 2019; Benavides-Varela et al., 2015; Duke Han et al., 2015; Griffith et al., 2010; Martin et al., 2019; Triebel et al., 2009). Furthermore, more years of education was related to a better performance on a measure of FDM in people living with MCI (Lui et al., 2013; Niccolai et al., 2017; Tolbert et al., 2019). Sex was not related to FDM performances of people living with MCI (Tolbert et al., 2019). Niccolai et al. (2017) finally reported that higher scores on a depression rating scale were related to a faster deterioration of FDM performances in people living with MCI over a two-years period. However, Arcara et al. (2019) did not find a significant association between financial capacity (measured with the NADL-F) and symptoms of depression in a mixed group of people living with MCI, healthy controls and people living with other neurological diseases.

3.3. Comparison of AD and MCI

Thirteen studies included people living with AD as well as people living with MCI, which allowed a direct comparison between these groups regarding their performances on tests of FDM. When comparing people living with AD and people living with MCI, it was found that people living with AD in the mild as well as in the moderate and severe stages, have more difficulties with FDM (i.e., total scores) than people living with MCI (Clark et al., 2014; Gerstenecker et al., 2017a, 2018, 2019; Giannouli et al., 2018; Giannouli and Tsolaki, 2014; Griffith et al., 2003; Lui et al., 2013; Marson et al., 2009; Martin et al., 2019; Pereira et al., 2010b; Sherod et al., 2009; Tolbert et al., 2019). This is in accordance with the significantly larger pooled mean effect size that was found for the comparison between people living with AD and healthy controls compared to the pooled mean effect size of the comparison between people living with MCI and healthy controls ($Q(1) = 48.4$, $p < .001$; Fig. 2).

Studies exploring the different aspects of FDM in more detail by examining the domains of the FCI, LCPLTAS or ACED, consistently reported that people living with AD showed more difficulties than people living with MCI on almost all domains of FDM (Gerstenecker et al., 2017a, 2018, 2019; Giannouli et al., 2018; Giannouli and Tsolaki, 2014; Griffith et al., 2003; Lui et al., 2013; Marson et al., 2009; Martin et al., 2019; Tolbert et al., 2019). However, Marson et al. (2009) and Giannouli et al. (2018) reported that while people living with moderate AD do show more difficulties with 'basic monetary skills' compared to people living with MCI, no differences were found on this domain of FDM between people living with mild AD and people living with MCI. Furthermore, some studies found no differences in performances between people living with mild AD and people living with MCI on the domains 'financial judgments' (Gerstenecker et al., 2017a; Griffith et al., 2003; Martin et al., 2019) and 'knowledge of personal assets' of the FCI (Griffith et al., 2003) and 'bill payment' of the LCPLTAS (i.e., means of the different groups differed < 2 SD; Giannouli et al., 2018).

3.4. Biological imaging techniques and FDM in people living with AD and people living with MCI

Five of the included studies also evaluated metabolic, molecular and structural imaging techniques in people living with AD and/or people living with MCI. Firstly, Griffith et al. (2007) investigated the relation between the metabolism of the posterior cingulate gyrus and FCI total score in people living with mild AD, using Proton Magnetic Resonance Spectroscopy. They mainly focused on the N-acetylaspartate/Creatine (NAA/Cr) ratio and the choline-containing compounds/Creatine (Cho/Cr) ratio. A decrease in NAA/Cr ratio indicates neuronal tissue loss or damage; an increase in Cho/Cr ratio indicates an increased demyelination (Schuff et al., 2006). After controlling for global cognition (i.e., Dementia Rating Scale total score), a mild to moderate positive correlation between NAA/Cr ratio and FDM and a moderate negative correlation between Cho/Cr ratio and FDM were found in people living with mild AD. However, after the exclusion of one potential outlier the negative correlation between Cho/CR and FCI was no longer significant. A second study (Griffith et al., 2010) explored the association between bilateral gray matter volumes of five regions of interests in people living with mild AD (i.e., the medial frontal cortex, the dorsolateral frontal cortex, the precunei, the angular gyri and the hippocampi) and FDM using Magnetic Resonance Imaging (MRI). A higher FCI total score was significantly, but moderately, associated with a larger volume of all regions of interest, except the hippocampi. Multiple regression, however, was used to control for the overlap or connections between brain

areas. The results indicated that only the volume of the medial frontal cortex was a significant predictor of FDM in people living with mild AD, i.e., predicting 35% of variance of the FCI total score. The association between white matter connectivity (using MRI based diffusion tensor imaging) and FDM was determined in a third study (Gerstenecker et al., 2017a). In people living with MCI, a greater degeneration of the white matter (i.e., a reduction of fractional anisotropy) in areas related to the precuneus, lateral and medial occipital, lateral temporal and lateral prefrontal cortices was related to lower performances on the FCI. In people living with mild AD, a decreased white matter integrity (i.e., increased axial diffusivity λ1 and mean diffusivity of λ1, λ2 and λ3) in similar regions as found in people living with MCI was related to lower FDM performances. In healthy controls, no relation between white matter connectivity and FDM was found. In a fourth study, Pereira et al. (2010b) investigated AD biomarkers (i.e., the concentrations of Total Tau, Phospho-Tau_{181} and Amyloid $ß_{1\text{-}42}$ in the cerebrospinal fluid) in nineteen people living with MCI and related these concentrations to performances on a measure of FDM (i.e., the DAFS subscale 'dealing with finances'). The results showed that higher concentrations of Total Tau and Phopsho-Tau_{181} were associated with lower performances on the tests of FDM in people living with MCI, whereas overall functional capacity (i.e., total score on DAFS) was not associated to any of these biomarkers. Finally, Tolbert et al. (2019) investigated FDM performances (i.e., on the FCI-SF) in relation to cortical ß-amyloid deposition. A higher cortical-to-cerebellum standardized uptake value ratio/SUVr indicates greater cortical ß-amyloid deposition which is described as one of the pathological hallmarks of AD and has the utility of predicting cognitive decline in normal aging and MCI (Clark et al., 2011; Doraiswamy et al., 2014). In a pooled sample of people living with MCI and people living with AD, while controlling for age, education and sex, higher ß-amyloid SUVr was significantly negatively correlated with FDM performances.

3.5. Frontotemporal Dementia (FTD)

Three studies, which included a total of 52 participants (weighted age = 67.3 years), investigated FDM in people living with FTD (Table 2c). All participants were diagnosed with the behavioral variant of FTD, although one study did not provide information about demographics and disease characteristics of participants (Giannouli et al., 2018). The included studies consistently found lower performances on tests of FDM compared to healthy controls (Giannouli et al., 2018; Gill et al., 2019; Lima-Silva et al., 2015). This is confirmed by the large pooled mean effect size found in the meta-analysis (i.e., $g = 2.56$ [1.73; 3.39], $SE = 0.42$, $p < .001$ based on three studies; Fig. 2). Significant heterogeneity was found ($Q(2) = 7.4$, $p = .025$, $I^2 = 73.0\%$) and the funnel plot showed significant asymmetry (p = .010; Fig. 3). However, only a small number of studies were included so these bias assessments should be interpreted with caution.

Gill et al. (2019) reported that people living with FTD showed an intact performance on 'reading/writing', 'rational beliefs about money' and 'debt management' of the FACT and FCAI compared to healthy controls. One study indicated that people living with FTD showed significantly lower FDM performances compared to people living with mild AD (i.e., deviation of ≥ 2 SD between groups on the 'total score', 'financial decision-making' and 'assets knowledge' domains of the LCPLTAS; Giannouli et al., 2018). Similar performances were, however, observed in people living with FTD and people in the moderate to severe stages of AD and when people living with FTD were compared with people living with AD who were matched based on their dementia severity (Giannouli et al., 2018; Lima-Silva et al., 2015). Furthermore, group differences between people living with FTD and people living with AD observed on the FACT and FCAI (Gill et al., 2019) were no longer significant when controlling for age. The association between FDM, cognition, age, sex, education and symptoms of depression has not been evaluated in people living with FTD.

3.6. Parkinson's Disease (PD)

Seven studies investigated FDM in people living with PD (Table 2d). Two studies (Pirogovsky et al., 2014, 2013) used the same sample which were, therefore, treated as one study. In total, 222 people living with PD participated in these studies and participants were on average between 66.7 and 75.6 years old (weighted age = 70.1 years). Participants were on their regular medication during assessment, however, three studies (Giannouli et al., 2018; Giannouli and Tsolaki, 2019, 2014) did not provide any information about disease characteristics and medication use of their sample.

All studies reported that people living with PD had significantly more difficulties with FDM than healthy controls (Giannouli et al., 2018; Giannouli and Tsolaki, 2019, 2014; Martin et al., 2013; Pirogovsky et al., 2014, 2013, 2012). This is in accordance with the large pooled mean effect size found in the meta-analysis (i.e., $g = 1.49$ [0.71; 2.27], $SE = 0.40$, $p < .001$, based on five studies; Fig. 2). Also for the PD studies, significant heterogeneity was found ($Q(4) = 58.8$, $p < .001$, $I^2 = 93.2\%$). The funnel plot showed no significant asymmetry (p = .333; Fig. 3).

3.6.1. The association between FDM and cognition in people living with PD

Most studies used total scores to evaluate FDM in people living with PD, however, whether specific domains of FDM are impaired seems to depend on the severity of cognitive impairments in people living with PD. When people living with PD are divided in groups with and without cognitive impairments, no differences are found between healthy controls and people living with PD without cognitive impairments regarding FDM (Pirogovsky et al., 2014). People living with PD meeting the criteria of MCI (PD-MCI) showed, however, significantly lower performances on tests of FDM than healthy controls (Martin et al., 2013; Pirogovsky et al., 2014), even though no differences were found between people living with PD-MCI and people living with PD without cognitive impairments (Pirogovsky et al., 2014). When exploring the performances of people living with PD in tests of FDM in more detail, it was found that people living with PD-MCI showed significantly lower performances on relatively basic aspects of FDM (i.e., 'basic monetary skills', 'financial concepts' and 'investment decision-making') compared to healthy controls. No group differences were found on other domains of the FCI between these groups (Martin et al., 2013). Problems with FDM were most consistently found in people living with PDD compared to healthy controls (Giannouli et al., 2018; Giannouli and Tsolaki, 2019; Martin et al., 2013). People living with PDD scored significantly lower than both healthy controls and people living with PD-MCI on almost all domains of FDM as measured with the FCI (Martin et al., 2013), even though 'financial judgment' and 'knowledge of assets/estate arrangement' seem to remain relatively intact in people living with PDD (i.e., no group differences were observed). In one study (Pirogovsky et al., 2012), seven people living with PDD were included in the sample, but the differences between people living with PD and healthy controls on the measure of FDM remained significant when excluding these people living with PDD. The remaining PD sample (n = 26) was described as non-demented, but it is unclear whether they suffered (mild) cognitive impairment(s). The researchers did report a direct moderate correlation between FDM and global cognition in people living with PD (Giannouli and Tsolaki, 2019; Pirogovsky et al., 2012). Another study, however, was not able to find a significant correlation between global cognition and FDM in people living with PD without dementia (Pirogovsky et al., 2014).

Two studies investigated the association between FDM and specific cognitive functions in people living with PD. Prospective memory, both time and event based, seems to be positively related to FDM in people living with PD (Pirogovsky et al., 2012). However, this correlation was no longer significant when people living with PDD were excluded from the sample. In accordance, when investigating people living with PD without dementia, no significant correlations were found between measures of attention, memory, executive functions, language and

visuospatial abilities and FDM (Pirogovsky et al., 2014, 2013; Table 3).

3.6.2. Influence of age, sex, education, symptoms of depression and disease characteristics in people living with PD

One study reported strong associations between age, sex and FDM in people living with PD (Pirogovsky et al., 2012). However, another study did not find any significant correlations between demographic characteristics and FDM in people living with PD (Pirogovsky et al., 2014). A more severe disease severity (i.e., higher Hoehn & Yahr scores) and a longer disease duration were weakly to moderately associated with lower scores on FDM in people living with PD (Pirogovsky et al., 2012). Another study could, however, not replicate these findings (Pirogovsky et al., 2013). One study found significantly lower FDM performances in people living with PDD with symptoms of depression compared to people living with PDD without symptoms of depression (Giannouli and Tsolaki, 2019). This corresponds with the weak to moderate associations found between symptoms of depression and lower scores on tests of FDM in people living with PD (Pirogovsky et al., 2013, 2012). People living with PD diagnosed with a major depressive disorder prior to the diagnosis of PD were, however, excluded in these studies.

3.7. Multiple Sclerosis (MS)

Only recently did researchers start examining FDM in people living with MS. Three studies were included in the review (Table 2e) as well as in the meta-analysis (Fig. 2). In total, 86 people living with MS participated in these studies and the average age ranged between 44.3 and 49.4 years (weighted age = 47.3 years). Gerstenecker et al. (2017b) included exclusively people living with MS with either a primary progressive or secondary progressive disease subtype, while the other two studies included a more mixed group with approximately half of the sample diagnosed with relapsing remitting MS and the other half with either primary progressive, secondary progressive or progressive relapsing MS or with a disease subtype that was uncertain (see Table 2e for more details).

All three studies (Gerstenecker et al., 2017b; Goverover et al., 2016; Tracy et al., 2017) concluded that people living with MS have more difficulties with FDM compared to healthy controls, which corresponds with the results of the meta-analysis ($g = 0.71$ [0.23; 1.16], $SE = 0.23$. $p < .001$). According to the meta-analysis, the effect size of one of the three studies was, however, not significant (Gerstenecker et al., 2017b; Fig. 2). The heterogeneity test was not significant ($Q(2) = 3.9$, $p = .141$, $I^2 = 49.0\%$) and the funnel plot showed no significant asymmetry ($p = .290$; Fig. 3). However, only a small number of studies were included so these bias assessments should be interpreted with caution.

Based on the AR test, which required skills such as planning and budgeting, people living with MS are more likely to make errors when using their credit card than healthy controls (Goverover et al., 2016). Furthermore, people living with MS also worked at a slower pace than healthy controls when performing this FDM test. However, people living with MS were equally able to 'stay within the price range', 'respond to unexpected situations' and 'to make appropriate decisions and choose financially the best options' (Goverover et al., 2016). Gerstenecker et al. (2017b) used the FCI to evaluate FDM in people living with MS and found that the performance of people living with MS was significantly lower than healthy controls on the total score and on almost all domains of the FCI (i.e., 'basic monetary skills, 'conceptual knowledge', 'cash transactions', 'checkbook management', 'bank statement management' and 'investment decision-making'). Group differences between people living with MS and healthy controls were not found for the domains 'financial judgment' and 'bill payment' of the FCI (Gerstenecker et al., 2017b).

3.7.1. The association between FDM and cognition in people living with MS

In the study of Tracy et al. (2017), people living with MS were divided in subgroups based on their cognitive abilities. Healthy controls and cognitively unaffected people living with MS did not differ with regard to their performances on the FCI. People living with MS with cognitive impairments (i.e., a performance of ≤1 SD on at least three neurocognitive tests), however, showed more difficulties with FDM than both cognitively unaffected people living with MS and healthy controls. On FCI domain level, cognitively impaired people living with MS had more difficulties with 'basic monetary skills', 'conceptual knowledge', 'checkbook management', 'bank statement management', 'bill payment' and 'investment decisions', than the other groups. However, the ability to perform 'cash transactions' and 'financial judgments' remained relatively intact since no group differences were observed.

All three studies (Gerstenecker et al., 2017b; Goverover et al., 2016; Tracy et al., 2017) investigated the associations between performances on tests of FDM and specific aspects of cognition (Table 3). In people living with MS, weak to moderate correlations were found between FDM tests and measures of attention, processing speed, language, memory (i.e., verbal and visual memory), arithmetic and executive functioning including mental flexibility and working memory, verbal reasoning (Gerstenecker et al., 2017b; Goverover et al., 2016; Tracy et al., 2017). Verbal memory and arithmetic explained 51.0% of variance of the FCI total score in people living with MS (Gerstenecker et al., 2017b). Goverover et al. (2016) calculated a total money management score based on their FDM performance-based test and a FDM self-report questionnaire and reported that processing speed was the only significant predictor of this total money management score, explaining 18.0% of variance.

3.7.2. Influence of age, sex, education, symptoms of depression and disease characteristics in people living with MS

No significant associations were found between FDM and age or education in people living with MS (Tracy et al., 2017). Also no significant associations were found between FDM and symptoms of depression (Gerstenecker et al., 2017b; Tracy et al., 2017) or anxiety (Goverover et al., 2016) in people living with MS. However, when the impact of motor disabilities on physical functioning in people living with MS increased, as measured with the Timed 25-Foot Walk, poorer performances on 'basic monetary skills' of the FCI were observed, although the association was weak (Tracy et al., 2017). Goverover et al. (2016), however, found no significant correlation between FDM and MS disease severity as measured with the Expanded Disability Status Score. Furthermore, group differences regarding FDM between people living with MS and healthy controls remained significant after controlling for upper extremity motor speed (Goverover et al., 2016). Sex in relation to FDM has not been studied in people living with MS.

3.8. Huntington's Disease (HD)

Only one study (Sheppard et al., 2017; Table 2f) investigated FDM in people living with HD and included 20 people living with symptomatic HD with a mild to moderate disease severity (based on the Unified Huntington's Disease Rating Scale; UHDRS) and compared them with 20 healthy controls. People living with HD had significantly more difficulties with FDM than healthy controls. Furthermore, a significant moderate positive correlation was observed between FDM and global cognition (Table 3). More specifically, the Mattis Dementia Rating Scale subtests initiation and perseveration, construction and memory were found to be significantly related to FDM in people living with HD. FDM was, however, not related to disease characteristics of HD (i.e., UHDRS total motor score) nor to symptoms of depression (i.e., Beck Depression Inventory-II and Geriatric Depression Scale short form). The associations between FDM and demographic variables, such as age, sex or education, were not evaluated in people living with HD.

4. Discussion

The aim of the present study was to provide a comprehensive

overview and meta-analysis of studies evaluating FDM in people living with an NDD. For this, the reliability of performance-based tests to consistently identify FDM difficulties in people living with an NDD compared to healthy controls was evaluated. Furthermore, if studies allowed, the performances on tests of FDM between groups with different NDDs was compared. Finally, the influence of disease severity and disease progression on FDM was explored, as well as the associations between FDM and performances on standard measures of cognition and demographic variables (i.e., age, sex and education). In the current review, FDM is used as a hypernym for every day knowledge, performances, skills and actions related to the use of money. Gambling or risk-taking were not taken into account. According to the conceptual model of financial capability (Appelbaum et al., 2016), gambling or risk-taking are contextual factors that may be of influence on financial competence and can result in a decreased financial performance in everyday life. Since the present review focuses specifically on the competence or capacity to make financial decisions, contextual factors such as gambling or risk-taking were, therefore, considered to be beyond the scope of this review. With the inclusion of 47 studies, the performances of people living with AD, MCI, FTD, PD, MS or HD could be compared to the performances of healthy controls. Meta-analyses were conducted within each group if more than one study could be included. The majority of studies included people living with AD and/or MCI (i.e., 38 studies in total).

4.1. FDM in people living an NDD

All included studies consistently reported more problems with FDM, based on performance-based tests, in people living with different NDDs compared to healthy controls. This is confirmed by the medium to large pooled mean effect sizes found for each group in the meta-analyses (no meta-analysis has been performed for people living with HD). The severity of cognitive decline in people living with an NDD seems to be related to the degree of problems with FDM. People living with AD, characterized by problems in multiple domains of cognition resulting in problems in daily life (American Psychiatric Association, 2013), have, for example, significantly more problems with FDM than people living with MCI (Gerstenecker et al., 2017a, 2018, 2019; Giannouli et al., 2018; Giannouli and Tsolaki, 2014; Griffith et al., 2003; Lui et al., 2013; Marson et al., 2009; Martin et al., 2019; Tolbert et al., 2019). This corresponds with the significantly larger pooled mean effect size found for people living with AD compared to people living with MCI. Also, over time, a significant deterioration of FDM performances is found in people living with MCI and people living with AD in longitudinal studies. Within this context, some domains of FDM seem to be less vulnerable to cognitive decline than others. In people living with MCI, the domains 'basic monetary skills' and 'financial judgment' of the FCI appear relatively intact since no differences were found compared to healthy controls (Gerstenecker et al., 2019, 2017a, 2016; Griffith et al., 2003). Both domains are described as relatively simple tasks of FDM (Griffith et al., 2003). Similar results are found for people living with mild AD (Gerstenecker et al., 2017a; Giannouli et al., 2018; Griffith et al., 2003; Loewenstein et al., 1989; Marson et al., 2000, 2009; Martin et al., 2019). However, when AD progresses to more advanced stages, significantly poorer performances are found on all assessed domains of FDM in people living with AD compared to people living with MCI and healthy controls. Also, when matched for their dementia severity (Lima-Silva et al., 2015) or when compared to people living with moderate to severe AD (Giannouli et al., 2018), people living with FTD and people living with AD show comparable performances on performance-based tests of FDM. Finally, also people living with PDD show more problems with FDM than people living with PD-MCI (Martin et al., 2013) and, interestingly, similar performances on FDM were found between healthy controls and people living with PD who were cognitively unaffected and people living with MS who were cognitively unaffected (Pirogovsky et al., 2014; Tracy et al., 2017).

The impact of cognition on FDM is further supported by the significant relations found between measures of global cognition and performances on tests of FDM in different NDD groups. The strength of these associations, however, differs between groups and seems to depend on the tests used for the assessment of FDM and global cognition. With regard to specific cognitive functions, especially working memory appears to be relevant for adequate performance on tests of FDM (e.g., Czaja et al., 2017; Earnst et al., 2001; Tracy et al., 2017; Table 3). Also processing speed and numeracy are consistently found to be related to FDM (e.g., Gerstenecker et al., 2017b; Griffith et al., 2010; Sherod et al., 2009; Table 3). According to the scientific literature and diagnostic guidelines (American Psychiatric Association, 2013), impairments in (verbal) memory and executive functions are predominantly present in typically amnestic syndromes (e.g., MCI and AD) and dysexecutive syndromes (e.g., FTD or PDD), respectively. These cognitive problems, however, seem to insufficiently explain the diminished performances on FDM in these groups since results with regard to the relation between both domains of cognition and FDM are inconsistent. This might explain why no profound differences appear to be present between the NDDs with regard to FDM.

Besides the relation between specific cognitive functions and FDM, also the associations between other potential determinants and FDM were evaluated in some studies. In people living with MCI, being younger and more years of education were found to be related to fewer difficulties with FDM (Duke Han et al., 2015; Lassen-Greene et al., 2017; Lui et al., 2013; Niccolai et al., 2017; Tolbert et al., 2019). An association between age and FDM was not found in people living with AD (Bassett, 1999; Mahurin et al., 1991; Martin et al., 2008). Significant group differences on measures of FDM between people living with AD and people living with FTD were, however, no longer significant when controlled for age (Gill et al., 2019), assuming some influence of age. The results with regard to the relation between sex, years of education and performances on measures of FDM in people living with AD are mixed (Bassett, 1999; Giannouli et al., 2018; Mahurin et al., 1991; Martin et al., 2008) and in the other NDDs these variables are insufficiently examined to draw conclusions. In people living with MS and people living with PD, studies found evidence that FDM is related to disease severity and motor disabilities (Pirogovsky et al., 2012; Tracy et al., 2017), but again results are mixed. Furthermore, some studies found a negative influence of symptoms of depression on FDM outcomes in people living with MCI and people living with PD (Niccolai et al., 2017; Pirogovsky et al., 2013, 2012). Within the context of other NDDs, this relation was absent or not studied. In most studies, however, clinically depressed people were excluded from the sample which makes the evaluation of the impact of this variable difficult.

In summary, even though there are some indications that FDM is associated with demographic variables and disease characteristics, overall, these associations are not evaluated systematically in the included studies. However, their potential influence on measures of FDM cannot be ruled out, especially since it is known that these variables have an influence on cognitive functioning (e.g., Murman, 2015; Van Der Elst et al., 2006b, 2006c, 2006a; Van Hooren et al., 2007). Therefore, future studies should control for group differences in these variables. Also, the impact of symptoms of depression on FDM is not well studied even though this variable might have a potential negative influence on performances on FDM. It is important to study this association in more detail since symptoms of depression are frequently present in people living with an NDD (Baquero and Martín, 2015). Furthermore, the influence of motor disabilities and disease severity in NDDs such as PD and MS should further be evaluated, especially when using performance-based tests that potentially require motor actions. Additional factors are also found to be of influence on someone's ability to make financial decisions, such as financial experience (Eberhardt et al., 2019; Marson et al., 2000) and income level (Bangma et al., 2017). Only a few of the included studies controlled for financial experience (Bassett, 1999; Griffith et al., 2003; Marson et al., 2000, 2009; Martin et al., 2008;

Sherod et al., 2009; Stoeckel et al., 2013; Triebel et al., 2009) and none of the studies examined other potential influential variables such as income level.

4.2. Evaluation of FDM tests

In total, nineteen different measures of FDM were used in the included studies. One of the most frequently used tests is the FCI (i.e., in 22 of 47 studies; Marson et al., 2000). Furthermore, the conceptual model of Appelbaum & Grisso (1988) is frequently used as a basis of FDM tests, e.g., for the FACT (Black et al., 2007) and ACED (Lai et al., 2008; Lai and Karlawish, 2007). Most tests simulate everyday FDM abilities, such as counting coins or paying bills. Some studies, however, used experimental tests or new scales to assess FDM. Consequently, psychometric properties of these tests are currently unknown. For some tests (i.e., FCI and DAFS) marked differences were observed between studies that used these tests, as different domains were included and total scores were calculated in different ways. With regard to the FCI, various versions have been developed over time, since new domains are introduced and different minimum and maximum scores are calculated for the same FCI domains (e.g., Earnst et al., 2001; Marson et al., 2000; Martin et al., 2008, 2019). This makes a direct comparison between studies that applied the FCI difficult.

A major problem that has been identified within the context of assessment of FDM is the lack of accessibility to tests measuring FDM which contributes to the development of new FDM tests (Engel et al., 2016). Even though differences in financial systems and procedures between countries sometimes require the development or adjustment of tests, more openness, collaboration and sharing test material is recommended to improve current and future tests focusing on FDM. Furthermore, the ecological validity of FDM tests remains unclear and it can, therefore, not be determined how performances on these tests can be translated to strengths and weaknesses within the context of money management in everyday life. For example, intact performance of people living with relatively mild cognitive disturbances, such as people living with MCI and mild AD, on specific domains of FDM tests suggest the preservation of some FDM skills. Possibly these people can function relatively well in everyday life when performing more basic FDM related actions, such as grocery shopping or paying bills, but need assistance with more complex tasks, such as buying property or taking out (health) insurance(s). Currently it is, however, not possible to formulate clear advice for people living with NDDs and their relatives based on FDM test performances. It also remains unclear whether a deterioration or decline in FDM, as observed in longitudinal studies, results in more everyday life problems. Ceiling effects are frequently found in healthy controls and the actual differences between groups are often very small in terms of scores or points on a test. Therefore, an important focus for further research is the ecological validity of FDM tests. The lack of normative data also complicates the use of performance-based FDM tests in clinical practice.

There are also other reasons why the formulation of (legal) decisions about someone's capacity to manage his or her finances is not possible solely based on performance-based FDM tests. First, it is unclear whether current FDM tests investigate all domains of financial competence. Recently, Engel et al. (2016) described nine domains of financial skills (e.g., basic monetary skills, paying bills, budgeting) and concluded that none of the currently available FDM tests examine all nine domains. Different theoretical models are used and there is major variability in content, type of tasks and administration between tests. More theoretical consensus and the development of more multidimensional FDM instruments, including both simple and complex financial skills, is therefore recommended. Furthermore, most FDM tests focus on either practical financial skills, financial knowledge or the ability to judge and make decisions, which are also described as someone's financial competence (Appelbaum et al., 2016). Financial competence or FDM, however, also relies on contextual factors and financial performances (i.e., the abilities and opportunities to implement financial decisions in everyday life; American Bar Association Commision on Law and Aging and American Psychological Association [ABA/APA], 2008; Appelbaum et al., 2016), which are both insufficiently assessed in current research. Finally, it is of utmost importance that decisions about a person's financial competence should be taken carefully to minimize the risk of, e.g., financial abuse. According to Engel et al. (2016), the currently available most useful tests for the evaluation of a person's financial competence are the FCI and SCIFC. Also, the LCPLTAS, which is based on the FCI, and the FCAI might be useful in this context. However, according to our knowledge, these tests have, so far, only been used in research and are not available for use in clinical practice. In order to make these tests suitable for clinical practice, more information about the clinimetrics of these tests is needed. Furthermore, as already mentioned, normative data is largely lacking. Only with this type of data, the performance on a financial competence test of an individual living with an NDD can be interpreted.

4.3. Limitations

Some limitations may be of influence on the conclusions drawn in the present study and need to be taken into account. First, there might be different interpretations of what is considered a performance-based test and what is considered a self and proxy report. According to the best of our knowledge, we included only performance-based tests of FDM and excluded all studies using self-report or proxy report assessments of FDM. However, only half of the tests included in this review were also identified as tests of FDM in a recent review identifying instruments to quantify financial management skills (Engel et al., 2016). One test included in this review (i.e., the ACED) was even described as a 'combined self-report and proxy report' measure of FDM. The ACED indeed partly contains a proxy evaluation of FDM. However, in the current review the other part of this test was considered as performance-based because of the way the test is administered and scored. Finally, some other tests (e.g., NADL-F or LCPLTAS) were published after the review of Engel et al. was conducted. Second, studies included in this review and meta-analyses vary in study design. For example, they vary in sample characteristics or FDM tests used. Furthermore, the diagnostic criteria for the different NDDs and the accuracy of diagnosis evolved over time. For example, the diagnostic criteria for dementia as described in the diagnostic and statistical manual of mental disorders (DSM) IV-TR changed to include minor and major neurocognitive disorders in the DSM-5 in 2013. Since the publication dates of the studies that were included in the present systematic review and meta-analysis ranges from 1989 to 2019, adaptations to diagnostic criteria and improvements in accuracy of diagnosis of NDDs most likely were of influence on the results found in the different studies. Consequently, the heterogeneity between studies is relatively high (I^2 ranged between 48.9% to 93.5%; Higgins et al., 2003). Random-effects methods instead of fixed-effects methods are used in the meta-analyses. Nevertheless, this unavoidable bias in clinical research might have been of influence on the results, so that the meta-analytic pooled mean effect sizes need to be interpreted with caution. Furthermore, the funnel plots (Fig. 3) cannot sufficiently confirm or exclude the possibility of publication bias because of the relatively small number of studies for each NDD group. Observed asymmetry might also be the result of heterogeneity between studies and the random-effects method used (Deeks et al., 2019). Third, the present study was not preregistered. For reasons of transparency, reproducibility and rigor this should have be done. Finally, no evaluation of the risk of bias has been executed. According to our knowledge, there is no valid and reliable tool available for the evaluation of the risk of bias for cross-sectional studies as included in the current review. The inability to appropriately evaluate the risk of bias and publication bias of the included studies, together with the moderate to high heterogeneity between studies, therefore need to be considered when interpreting the results.

4.4. Conclusion

Taking these limitations into account, there is ample evidence that people living with an NDD are vulnerable for impairments in their capacity to make financial decisions. FDM performance in people living with an NDD appears to be related to cognitive decline, specifically in working memory, processing speed and numeracy. However, the number of studies focusing on FDM in people living with an NDD other than AD or MCI are limited or have not been performed to date. Further research is thus necessary to further elaborate this topic. Furthermore, the associations between the observed problems with FDM and difficulties in everyday life remain unclear. It is conceivable that problems with FDM can lead to major negative consequences in the everyday lives of people with living with an NDD and their relatives and can result in debts or poverty. A focus on more multidimensional research on FDM and an emphasis on the ecological validity of current and new FDM tests is therefore recommended.

Declaration of Competing Interest

None.

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Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.neubiorev.2021.05.021.

References

Albert, M.S., DeKosky, S.T., Dickson, D., Dubois, B., Feldman, H.H., Fox, N.C., Phelps, C. H., 2011. The diagnosis of mild cognitive impairment due to Alzheimer's disease: Recommendations from the National Institute on Aging and Alzheimer's Association workgroup. Alzheimers Dement. 7, 270–279. https://doi.org/10.1016/j.jalz.2011.03.008.

American Bar Association Commision on Law and Aging and American Psychological Association [ABA/APA], 2008. Assessment of Older Adults with Diminished Capacity: A Handbook for Psychologists. American Bar Association, Washington, DC.

American Psychiatric Association, 2013. Diagnostic and statistical manual of mental disorders, 5th Ed. American Psychiatric Association, Arlington, VA.

Appelbaum, P.S., Grisso, T., 1988. Assessing patients' capacities to consent to treatment. N. Engl. J. Med. 319, 695–699.

Appelbaum, P.S., Spicer, C.M., Valliere, F.R., 2016. Informing Social Security's Process for Financial Capability Determination. The National Academies Press, Washington, DC.

Arcara, G., Burgio, F., Benavides-Varela, S., Toffano, R., Gindri, P., Tonini, E., Meneghello, F., Semenza, C., 2019. Numerical Activities of Daily Living—Financial (NADL-F): A tool for the assessment of financial capacities. Neuropsychol. Rehabil. 29, 1062–1084. https://doi.org/10.1080/09602011.2017.1359188.

Bangen, K.J., Jak, A.J., Schiehser, D.M., Delano-Wood, L., Tuminello, E., Han, S.D., Delis, D.C., Bondi, M.W., 2010. Complex activities of daily living vary by mild cognitive impairment subtype. J. Int. Neuropsychol. Soc. 16, 630–639. https://doi.org/10.1017/s1355617710000330.

Bangma, D.F., Fuermaier, A.B.M., Tucha, L., Tucha, O., Koerts, J., 2017. The effects of normal aging on multiple aspects of financial decision-making. PLoS One 12, e0182620. https://doi.org/10.1371/journal.pone.0182620.

Baquero, M., Martín, N., 2015. Depressive symptoms in neurodegenerative diseases. World J. Clin. Cases 3, 682–693. https://doi.org/10.12998/wjcc.v3.i8.682.

Bassett, S.S., 1999. Attention: Neuropsychological predictor of competency in Alzheimer's disease. J. Geriatr. Psychiatry Neurol. 12, 200–205.

Beglinger, L.J., O'Rourke, J.J.F., Wang, C., Langbehn, D.R., Duff, K., Paulsen, J.S., 2010. Earliest functional declines in Huntington disease. Psychiatry Res. 178, 414–418. https://doi.org/10.1016/j.psychres.2010.04.030.

Benavides-Varela, S., Burgio, F., Meneghello, F., De Marco, M., Arcara, G., Rigon, J., Pilosio, C., Butterworth, B., Venneri, A., Semenza, C., 2015. Anatomical substrates and neurocognitive predictors of daily numerical abilities in mild cognitive impairment. Cortex 71, 58–67. https://doi.org/10.1016/j.cortex.2015.05.031.

Black, E., Ross, T., Flanagan, T., Rabheru, K., Breiter, H., 2007. A financial assessment & capacity test (FACT) for a psychogeriatric population. Res. Insignts Reg. Ment. Heal. Care, London/St. THomas 4, 1–22.

Borenstein, M., Hedges, L.V., Higgins, J.P.T., Rothstein, H., 2009. Introduction to Meta-Analysis. Wiley, Chichester.

Chen, Y., Wang, J., Kirk, R.M., Pethtel, O.L., Kiefner, A.E., 2014. Age Differences in Adaptive Decision Making: The Role of Numeracy. Educ. Gerontol. 40, 825–833. https://doi.org/10.1080/03601277.2014.900263.

Chiaravalloti, N.D., DeLuca, J., 2008. Cognitive impairment in multiple sclerosis. Lancet Neurol. 7 (12), 1139–1151. https://doi.org/10.1016/S14744422(08)70259-X.

Clark, C.M., Schneider, J.A., Bedell, B.J., Beach, M.D., Bilker, W.B., Mintun, M.A., Pontecorvo, M.J., Hefti, F., Carpenter, A.P., Flitter, M.L., Krautkramer, M.J., Kung, H.F., Coleman, E., Doraiswamy, M., Fleisher, A.S., Sabbagh, M.N., Sadowsky, C.H., Reiman, E.M., Zehntner, S.P., Skovronsky, D.M., for the AV45-AO7 Study Group, 2011. Use of florbetapir-PET for imaging beta-amyloid pathology. JAMA 305, 275–283. https://doi.org/10.1001/jama.2010.2008.

Clark, D.G., Kapur, P., Geldmacher, D.S., Brockington, J.C., Harrell, L., DeRamus, T.P., Blanton, P.D., Lokken, K., Nicholas, A.P., Marson, D.C., 2014. Latent information in fluency lists predicts functional decline in persons at risk for Alzheimer disease. Cortex 55, 202–218. https://doi.org/10.1016/j.cortex.2013.12.013.

Czaja, S.J., Loewenstein, D.A., Sabbag, S.A., Curiel, R.E., Crocco, E., Harvey, P.D., 2017. A Novel Method for Direct Assessment of Everyday Competence among Older Adults. J. Alzheimer's Dis. 57, 1229–1238. https://doi.org/10.3233/JAD-161183.

Deeks, J.J., Higgins, J.P.T., Altman, D.G., 2019. Chapter 10: Analysing data and undertaking meta-analyses. In: Higgins, J.P.T., Thomas, J., Chandler, J., Cumpston, M., Li, T., Page, M.J., Welch, V.A. (Eds.), Cochrane Handbook for Systematic Reviews of Interventions. Cochrane.

Doraiswamy, P.M., Sperling, R.A., Johnson, K., Reiman, E.M., Wong, T.Z., Sabbagh, M. N., Sadowsky, C.H., Fleisher, A.S., Carpenter, A., Joshi, A.D., Lu, M., Grundman, M., Mintun, M.A., Skovronsky, D.M., Pontecorvo, M.J., Duara, R., Sabbagh, M., Ahern, G.L., Holub, R.F., Farmer, M.V., Safirstein, B.E., Alva, G., Longmire, C.F., Jewell, G., Johnson, K.A., Korn, R., Wendt, J.K., Wong, D., Coleman, R.E., Devous, M., Jennings, D., Weiner, M.W., Murphy, C.A., Kovnat, K.D., Williamson, J. D., 2014. Florbetapir F 18 amyloid PET and 36-month cognitive decline:a prospective multicenter study. Mol. Psychiatry 19, 1044–1051. https://doi.org/10.1038/mp.2014.9.

Duke Han, S., Boyle, P.A., James, B.D., Yu, L., Bennett, D.A., 2015. Mild cognitive impairment is associated with poorer decision-making in community-based older persons. J. Am. Geriatr. Soc. 63, 676–683. https://doi.org/10.1111/jgs.13346.

Earnst, K.S., Wadley, V.G., Aldridge, T.M., Boothe Steenwyk, A., Hammond, A.E., Harrell, L.E., Marson, D.C., 2001. Loss of financial capacity in Alzheimer's disease: The role of working memory. Aging, Neuropsychol. Cogn. 8, 109–119. https://doi.org/10.1076/anec.8.2.109.839.

Eberhardt, W., Bruine de Bruin, W., Strough, J.N., 2019. Age differences in financial decision making: The benefits of more experience and less negative emotions. J. Behav. Decis. Mak. 32, 79–93. https://doi.org/10.1002/bdm.2097.

Egger, M., Smith, G.D., Schneider, M., Minder, C., 1997. Bias in meta-analysis detected by a simple, graphical test. Br. Med. J. 315, 629–637.

Engel, L., Bar, Y., Beaton, D.E., Green, R.E., Dawson, D.R., 2016. Identifying instruments to quantify financial management skills in adults with acquired cognitive impairments. J. Clin. Exp. Neuropsychol. 38, 76–95. https://doi.org/10.1080/13803395.2015.1087468.

Finucane, M.L., Gullion, C.M., 2010. Developing a tool for measuring the decision-making competence of older adults. Psychol. Aging 25, 271–288. https://doi.org/10.1037/a0019106.

Fritz, C.O., Morris, P.E., Richler, J.J., 2012. Effect size estimates: Current use, calculations, and interpretation. J. Exp. Psychol. Gen. 141, 2–18. https://doi.org/10.1037/a0024338.

Fuermaier, A.B.M., Tucha, L., Koerts, J., Aschenbrenner, S., Hauser, J., Weisbrod, M., Lange, K.W., Tucha, O., Fuermaier, A.B.M., Tucha, L., Aschenbrenner, S., Weisbrod, M., Lange, K.W., Tucha, O., 2014. Neuropsychology Cognitive Impairment in Adult ADHD – Perspective Matters! Neuropsychology 29, 45–58. https://doi.org/10.1037/neu0000108.

Gorno-Tempini, M.L., Hillis, A.E., Weintraub, S., Kertesz, A., Mendez, M., Cappa, S.F., Ogar, J.M., Rohrer, J.D., Black, S., Boeve, B.F., Manes, F., Dronkers, N.F., Vandenberghe, R., Rascovsky, J., Patterson, K., Miller, B.L., Knopman, D.S., Hodges, J.R., Mesulam, M.M., Grossman, M., 2011. Classification of primary progressive aphasia and its variants. Neurology 76 (11), 1006–1014. https://doi.org/10.1212/WNL.0b013e31821103e6.

Gerstenecker, A., Hoagey, D.A., Marson, D.C., Kennedy, K.M., 2017a. White matter degradation is associated with reduced financial capacity in mild cognitive impairment and Alzheimer's disease. J. Alzheimer's Dis. 60, 537–547. https://doi.org/10.3233/JAD-170341.

Gerstenecker, A., Martin, R.C., Triebel, K.L., Marson, D.C., 2019. Anosognosia of financial ability in mild cognitive impairment. Int. J. Geriatr. Psychiatry 34, 1200–1207. https://doi.org/10.1002/gps.5118.

Gerstenecker, A., Myers, T., Lowry, K., Martin, R.C., Triebel, K.L., Bashir, K., Marson, D. C., 2017b. Financial Capacity and its Cognitive Predictors in Progressive Multiple Sclerosis. Arch. Clin. Neuropsychol. 32, 943–950. https://doi.org/10.1093/arclin/acx039.

Gerstenecker, A., Triebel, K., Eakin, A., Martin, R., Marson, D., 2018. Exploring the factor structure of financial capacity in cognitively normal and impaired older adults. Clin. Gerontol. 41, 33–41. https://doi.org/10.1080/07317115.2017.1387211.

Gerstenecker, A., Triebel, K.L., Martin, R., Snyder, S., Marson, D.C., 2016. Both financial and cognitive decline predict clinical progression in MCI. Alzheimer Dis. Assoc. Disord. 30, 27–34. https://doi.org/10.1097/WAD.0000000000000120.

Giannouli, V., Stamovlasis, D., Tsolaki, M., 2018. Exploring the role of cognitive factors in a new instrument for elders' financial capacity assessment. J. Alzheimer's Dis. 62, 1579–1594. https://doi.org/10.3233/JAD-170812.

Giannouli, V., Tsolaki, M., 2019. Depression and financial capacity assessment in Parkinson's disease with dementia: Overlooking an important factor? Psychiatriki 30, 66–70.
Giannouli, V., Tsolaki, M., 2014. Legal capacity of the elderly in Greece. Hell. J. Nucl. Med. 17 (Suppl 1), 2–6.
Gill, S., Blair, M., Kershaw, M., Jesso, S., MacKinley, J., Coleman, K., Pantazopoulos, K., Pasternak, S., Finger, E., 2019. Financial capacity in frontotemporal dementia and related presentations. J. Neurol. 266, 1698–1707. https://doi.org/10.1007/s00415-019-09317.
Glimcher, P.W., Glimcher, P.W., 2014. Introduction to Neuroscience. In: Fehr, E. (Ed.), Neuroeconomics: Decision Making and the Brain. Elsevier Academic Press, San Diago, CA, US, pp. 63–76.
Goverover, Y., DeLuca, J., 2015. Actual reality: Using the Internet to assess everyday functioning after traumatic brain injury. Brain Inj. 29, 715–721. https://doi.org/10.3109/02699052.2015.1004744.
Goverover, Y., Haas, S., DeLuca, J., 2016. Money Management Activities in Persons with Multiple Sclerosis. Arch. Phys. Med. Rehabil. 97, 1901–1907. https://doi.org/10.1016/j.apmr.2016.05.003.
Goverover, Y., O'Brien, A.R., Moore, N.B., DeLuca, J., 2010. Actual Reality: A New Approach to Functional Assessment in Persons With Multiple Sclerosis. Arch. Phys. Med. Rehabil. 91, 252–260. https://doi.org/10.1016/j.apmr.2009.09.022.
Griffith, H.R., Belue, K., Sicola, A., Krzywanski, S., Zamrini, E., Harrell, L., Marson, D.C., 2003. Impaired financial abilities in mild cognitive impairment: a direct assessment approach. Neurology 60, 449–457.
Griffith, H.R., Okonkwo, O.C., den Hollander, J.A., Belue, K., Lanza, S., Harrell, L.E., Brockington, J.C., Clark, D.G., Marson, D.C., 2007. Brain proton mrs is correlated with financial abilities in patients with Alzheimer's disease. Brain Imaging Behav. 1, 23–29. https://doi.org/10.1007/s11682-007-9002-3.
Griffith, H.R., Stewart, C.C., Stoeckel, L.E., Okonkwo, O.C., Den Hollander, J.A., Martin, R.C., Belue, K., Copeland, J.N., Harrell, L.E., Brockington, J.C., Clark, D.G., Marson, D.C., 2010. Magnetic resonance imaging volume of the angular gyri predicts financial skill deficits in people with amnestic mild cognitive impairment. J. Am. Geriatr. Soc. 58, 265–274. https://doi.org/10.1111/j.1532-5415.2009.02679.x.
Hardiman, O., Doherty, C.P., 2016. Neurodegenerative disorders: a clinical guide, 2nd ed. Springer International Publishing, Switzerland.
Heaton, R.K., Marcotte, T.D., Rivera Mindt, M., Sadek, J., Moore, D.J., Bentley, H., Mccutchan, J.A., Reicks, C., Grant, I, Group, H, 2004. The impact of HIV-associated neuropsychological impairment on everyday functioning. J. Int. Neuropsychol. Soc. 10, 317–331. https://doi.org/10.1017/S1355617704102130.
Hely, M.A., Reid, W.G., Adena, M.A., Halliday, G.M., Morris, J.G., 2008. The Sydney multicenter study of Parkinson's disease: the inevitability of dementia at 20 years. Mov. Disord. 23 (6), 837–844. https://doi.org/10.1002/mds.21956.
Higgins, J.P.T., Thompson, S.G., Deeks, J.J., Altman, D.G., 2003. Measuring inconsistency in meta-analyses. Br. Med. J. 327, 557–560. https://doi.org/10.1136/bmj.327.7414.557.
Kennerley, S.W., Walton, M.E., 2011. Decision making and reward in frontal cortex: Complementary evidence from neurophysiological and neuropsychological studies. Behav. Neurosci. 125, 297–317. https://doi.org/10.1037/a0023575.
Kenney, L.E., Margolis, S.A., Davis, J.D., Tremont, G., 2019. The Screening Utility and Ecological Validity of the Neuropsychological Assessment Battery Bill Payment Subtest in Older Adults with and without Dementia. Arch. Clin. Neuropsychol. Off. J. Natl. Acad. Neuropsychol. 34, 1156–1164. https://doi.org/10.1093/arclin/acz033.
Kershaw, M.M., Webber, L.S., 2008. Assessment of financial competence. Psychiatry, Psychol. Law 15, 40–55. https://doi.org/10.1080/13218710701873965.
Koerts, J., van Beilen, M., Leenders, K.L., Brouwer, W.H., Tucha, L., Tucha, O., 2012. Complaints about impairments in executive functions in Parkinson's disease: The association with neuropsychological assessment. Park. Relat. Disord. 18, 194–197. https://doi.org/10.1016/j.parkreldis.2011.10.002.
Lai, J.M., Gill, T.M., Cooney, L.M., Bradley, E.H., Ph, D., Hawkins, K.A., Karlawish, J.H., 2008. Everyday Decision-Making Ability in Older Persons With Cognitive Impairment. Am. J. Geriatr. Psychiatry 16, 693–696. https://doi.org/10.1097/01.JGP.0000239246.10056.2e.
Lai, J.M., Karlawish, J., 2007. Assessing the capacity to make everyday decisions: A guide for clinicians and an agenda for future research. Am. J. Geriatr. Psychiatry 15, 101–111. https://doi.org/10.1097/01.JGP.0000239246.10056.2e.
Lassen-Greene, C.L., Steward, K., Okonkwo, O., Porter, E., Crowe, M., Vance, D.E., Griffith, H.R., Ball, K., Marson, D.C., Wadley, V.G., 2017. Mild cognitive impairment and changes in everyday function over time: The importance of evaluating both speed and accuracy. J. Geriatr. Psychiatry Neurol. 30, 220–227. https://doi.org/10.1177/0891988717711807.
Lima-Silva, T.B., Bahia, V.S., Carvalho, V.A., Guimarães, H.C., Caramelli, P., Balthazar, M.L.F., Damasceno, B., Bottino, C.M.D.C., Brucki, S.M.D., Nitrini, R., Yassuda, M.S., 2015. Direct and indirect assessments of activities of daily living in behavioral variant frontotemporal dementia and Alzheimer disease. J. Geriatr. Psychiatry Neurol. 28, 19–26. https://doi.org/10.1177/0891988714541874.
Litvan, I., Aarsland, D., Adler, C.H., Goldman, J.G., Kulisevsky, J., Mollenhauer, B., Rodriguez-Oroz, M.C., Tröster, A.I., Weintraub, D., 2011. MDS Task Force on mild cognitive impairment in Parkinson's disease: a critical review of PD-MCI. Mov. Disord. 26 (10), 1814–1824. https://doi.org/10.1002/mds.23823.
Litvan, I., Mega, M.S., Cummings, J.L., Fairbanks, L., 1996. Neuropsychiatric aspects of progressive supranuclear palsy. Neurology 47 (5), 1184–1189. https://doi.org/10.1212/WNL.47.5.1184.
Loeb, P.A., 1996. ILS: Independent living scale manual. Psychological Corporation, Harcout Brace Jovanovich, San Antonio, TX.
Loewenstein, D.A., Amigo, E., Duara, R., Guterman, A., Hurwitz, D., Berkowitz, N., Wilkie, F., Weinberg, G., Black, B., Gittelman, B., Eisdorfer, C., 1989. A New Scale for the Assessment of Functional Status in Alzheimer's Disease and Related Disorders. J. Gerontol. 44, 114–121.
Loewenstein, D.A., Duara, R., Mark, R., Argüelles, T., Lapinski, K.J., Eisdorfer, C., 1995. Deterioration of Functional Capacities in Alzheimer's Disease After a 1-Year Period. Int. Psychogeriatrics 7, 495–503. https://doi.org/10.1017/S1041610295002237.
Lomen-Hoerth, C., 2011. Clinical phenomenology and neuroimaging correlates in ALS-FTD. J. Mol. Neurosci. 45 (3), 656–662. https://doi.org/10.1007/s12031-011-9636-x.
Lui, V.W.C., Lam, L.C.W., Chau, R.C.M., Fung, A.W.T., Wong, B.M.L., Leung, G.T.Y., Leung, K.F., Chiu, H.F.K., Karlawish, J.H.T., Appelbaum, P.S., 2013. Structured assessment of mental capacity to make financial decisions in Chinese older persons with mild cognitive impairment and mild Alzheimer disease. J. Geriatr. Psychiatry Neurol. 26, 69–77. https://doi.org/10.1177/0891988713481268.
Mahurin, R.K., DeBettignies, B.H., Pirozzolo, F.J., 1991. Structured assessment of independent living skills: Preliminary report of a performance measure of functional abilities in dementia. Journals Gerontol. 46, 58–66. https://doi.org/10.1093/geronj/46.2.P58.
Manthorpe, J., Samsi, K., Rapaport, J., 2012. Responding to the financial abuse of people with dementia: A qualitative study of safeguarding experiences in England. Int. Psychogeriatrics 24, 1454–1464. https://doi.org/10.1017/S1041610212000348.
Marson, D.C., Martin, R.C., Wadley, V., Griffith, H.R., Snyder, S., Goode, P.S., Kinney, F. C., Nicholas, A.P., Steele, T., Anderson, B., Zamrini, E., Raman, R., Bartolucci, A., Harrell, L.E., 2009. Clinical interview assessment of financial capacity in older adults with mild cognitive impairment and Alzheimer's disease. J. Am. Geriatr. Soc. 57, 806–814. https://doi.org/10.1111/j.1532-5415.2009.02202.x.
Marson, D.C., Sawrie, S.M., Snyder, S., McInturff, B., Stalvey, T., Boothe, A., Aldridge, T., Chatterjee, A., Harrell, L.E., 2000. Assessing Financial Capacity in Patients With Alzheimer Disease: A conceptual model and prototype instrument. Arch. Neurol. 57, 877–884. https://doi.org/10.1001/archneur.57.6.877.
Martin, R., Griffith, H.R., Belue, K., Harrell, L., Zamrini, E., Anderson, B., Bartolucci, A., Marson, D.C., 2008. Declining financial capacity in patients with mild Alzheimer disease: A one-year longitudinal study. Am. J. Geriatr. Psychiatry 16, 209–219. https://doi.org/10.1097/JGP.0b013e318157cb00.
Martin, R.C., Gerstenecker, A., Triebel, K.L., Falola, M., McPherson, T., Cutter, G., Marson, D.C., 2019. Declining financial capacity in mild cognitive impairment: A six-year longitudinal study. Arch. Clin. Neuropsychol. 34, 152–161. https://doi.org/10.1093/arclin/acy030.
Martin, R.C., Triebel, K., Dreer, L.E., Novack, T.A., Turner, C., Marson, D.C., 2012. Neurocognitive predictors of financial capacity in traumatic brain injury. J. Head Trauma Rehabil. 27 https://doi.org/10.1097/HTR.0b013e318273de49.
Martin, R.C., Triebel, K.L., Kennedy, R.E., Nicholas, A.P., Watts, R.L., Stover, N.P., Brandon, M., Marson, D.C., 2013. Impaired financial abilities in Parkinson's disease patients with mild cognitive impairment and dementia. Park. Relat. Disord. 19, 986–990. https://doi.org/10.1016/j.parkreldis.2013.06.017.
McKeith, I.G., Dickson, D.W., Lowe, J., Emre, M., O'Brien, J.T., Feldman, H., Cummings, J., Duda, J.E., Lippa, C., Perry, E.K., Aarsland, D., Arai, H., Ballard, C.G., Boeve, B., Burn, D.J., Costa, D., Del Ser, T., Dubois, B., Galasko, D., Gauthier, S., Goetz, C.G., Gomez-Tortosa, E., Halliday, G., Hansen, L.A., Hardy, J., Iwatsubo, T., Kalaria, R.N., Kaufer, D., Kenny, R.A., Korczyn, A., Kosaka, K., Lee, V.M., Lees, A., Litvan, I., Londos, E., Lopez, O.L., Minoshima, S., Mizuno, Y., Molina, J.A., Mukaetova-Ladinska, E.B., Pasquier, F., Perry, R.H., Schulz, J.B., Trojanowski, J.Q., Yamada, M., Consortium on DLB, 2005. Diagnosis and management of dementia with Lewy bodies: third report of the DLB Consortium. Neurology 65 (12), 1863–1872. https://doi.org/10.1212/01.wnl.0000187889.17253.b1.
Middleton, L.S., Denney, D.R., Lynch, S.G., Parmenter, B., 2006. The relationship between perceived and objective cognitive functioning in multiple sclerosis. Arch. Clin. Neuropsychol. 21, 487–494. https://doi.org/10.1016/j.acn.2006.06.008.
Moher, D., Liberati, A., Tetzlaff, J., Altman, D.G., Altman, D., Antes, G., Atkins, D., Barbour, V., Barrowman, N., Berlin, J.A., Clark, J., Clarke, M., Cook, D., D'Amico, R., Deeks, J.J., Devereaux, P.J., Dickersin, K., Egger, M., Ernst, E., Gøtzsche, P.C., Grimshaw, J., Guyatt, G., Higgins, J., Ioannidis, J.P.A., Kleijnen, J., Lang, T., Magrini, N., McNamee, D., Moja, L., Mulrow, C., Napoli, M., Oxman, A., Pham, B., Rennie, D., Sampson, M., Schulz, K.F., Shekelle, P.G., Tovey, D., Tugwell, P., 2009. Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement. PLoS Med. 6 https://doi.org/10.1371/journal.pmed.1000097.
Moore, D.J., Palmer, B.W., Patterson, T.L., Jeste, D.V., 2007. A review of performance-based measures of functional living skills. J. Psychiatr. Res. 41, 97–118. https://doi.org/10.1016/j.jpsychires.2005.10.008.
Murman, D.L., 2015. The Impact of Age on Cognition. Semin. Hear. 36, 111–121. https://doi.org/10.1055/s-0035-1555115.
Niccolai, L.M., Triebel, K.L., Gerstenecker, A., McPherson, T.O., Cutter, G.R., Martin, R. C., Marson, D.C., 2017. Neurocognitive Predictors of Declining Financial Capacity in Persons with Mild Cognitive Impairment. Clin. Gerontol. 40, 14–23. https://doi.org/10.1080/07317115.2016.1228022.
Okonkwo, O.C., Griffith, H.R., Vance, D.E., Marson, D.C., Ball, K.K., Wadley, V.G., 2009. Awareness of functional difficulties in mild cognitive impairment: A multidomain assessment approach. J. Am. Geriatr. Soc. 57, 978–984. https://doi.org/10.1111/j.1532-5415.2009.02261.x.
Okonkwo, O.C., Wadley, V.G., Griffith, H.R., Ball, K., Marson, D.C., 2006. Cognitive correlates of financial abilities in mild cognitive impairment. J. Am. Geriatr. Soc. 54, 1745–1750. https://doi.org/10.1111/j.1532-5415.2006.00916.x.
Okonkwo, O.C., Wadley, V.G., Griffith, H.R., Belue, K., Lanza, S., Zamrini, E.Y., Harrell, L.E., Brockington, J.C., Clark, D., Raman, R., Marson, D.C., 2008. Awareness of deficits in financial abilities in patients with mild cognitive impairment: Going beyond self-informant discrepancy. Am. J. Geriatr. Psychiatry 16, 650–659. https://doi.org/10.1097/JGP.0b013e31817e8a9d.

Patterson, T.L., Goldman, S., McKibbin, C.L., Hughs, T., Jeste, D.V., 2001. UCSD Performance-Based Skills Assessment: Development of a New Measure of Everyday Functioning for Severely Mentally Ill Adults. Schizophr. Bull. 27, 235–245. https://doi.org/10.1093/oxfordjournals.schbul.a006870.

Pereira, F.S., Oliveira, A.M., Diniz, B.S., Forlenza, O.V., Yassuda, M.S., 2010a. Cross-cultural adaptation, reliability and validity of the DAFS-R in a sample of Brazilian older adults. Arch. Clin. Neuropsychol. 25, 335–343. https://doi.org/10.1093/arclin/acq029.

Pereira, F.S., Yassuda, M.S., Oliveira, A.M., Diniz, B.S., Radanovic, M., Talib, L.L., Gattaz, W.F., Forlenza, O.V., 2010b. Profiles of functional deficits in mild cognitive impairment and dementia: Benefits from objective measurement. J. Int. Neuropsychol. Soc. 16, 297–305. https://doi.org/10.1017/S1355617709991330.

Pérès, K., Helmer, C., Amieva, H., Orgogozo, J.M., Rouch, I., Dartigues, J.F., Barberger-Gateau, P., 2008. Natural history of decline in instrumental activities of daily living performance over the 10 years preceding the clinical diagnosis of dementia: A prospective population-based study. J. Am. Geriatr. Soc. 56, 37–44. https://doi.org/10.1111/j.1532-5415.2007.01499.x.

Pirogovsky, E., Martinez-Hannon, M., Schiehser, D.M., Lessig, S.L., Song, D.D., Litvan, I., Filoteo, J.V., 2013. Predictors of performance-based measures of instrumental activities of daily living in nondemented patients with Parkinson's disease. J. Clin. Exp. Neuropsychol. 35, 926–933. https://doi.org/10.1080/13803395.2013.838940.

Pirogovsky, E., Schiehser, D.M., Obtera, K.M., Burke, M.M., Lessig, S.L., Song, D.D., Litvan, I., Filoteo, J.V., 2014. Instrumental activities of daily living are impaired in parkinson's disease patients with mild cognitive impairment. Neuropsychology 28, 229–237. https://doi.org/10.1037/neu0000045.

Pirogovsky, E., Woods, S.P., Filoteo, J.V., Gilbert, P.E., 2012. Prospective memory deficits are associated with poorer everyday functioning in Parkinson's disease. J. Int. Neuropsychol. Soc. 18, 986–995. https://doi.org/10.1017/S1355617712000781.

Rascovsky, K., Hodges, J.R., Knopman, D., Mendez, M.F., Kramer, J.H., Neuhaus, J., van Swieten, J.C., Seelaar, H., Dopper, E.G., Onyike, C.U., Hillis, A.E., Josephs, K.A., Boeve, B.F., Kertesz, A., Seeley, W.W., Rankin, K.P., Johnson, J.K., Gorno-Tempini, M.L., Rosen, H., Prioleau-Latham, C.E., Lee, A., Kipps, C.M., Lillo, P., Piguet, O., Rohrer, J.D., Rossor, M.N., Warren, J.D., Fox, N.C., Galasko, D., Salmon, D.P., Black, S.E., Mesulam, M., Weintraub, S., Dickerson, B.C., Diehl-Schmid, J., Pasquier, F., Deramecourt, V., Lebert, F., Pijnenburg, Y., Chow, T.W., Manes, F., Grafman, J., Cappa, S.F., Freedman, M., Grossman, M., Miller, B.L., 2011. Sensitivity of revised diagnostic criteria for the behavioural variant of frontotemporal dementia. Brain 134, 2456–2477. https://doi.org/10.1093/brain/awr179.

Reyna, V.F., Nelson, W.L., Han, P.K., Dieckmann, N.F., 2009. How Numeracy Influences Risk Comprehension and Medical Decision Making. Psychol. Bull. 135, 943–973. https://doi.org/10.1037/a0017327.

Reitz, C., Brayne, C., Mayeux, R., 2011. Epidemiology of Alzheimer disease. Nat. Rev. Neurol. 7 (3), 137–152. https://doi.org/10.1038/nrneurol.2011.2.

Ross, C.A., Tabrizi, S.J., 2011. Huntington's disease: from molecular pathogenesis to clinical treatment. Lancet Neurol. 10 (1), 83–98. https://doi.org/10.1016/S1474-4422(10)70245-3.

Schuff, N., Meyerhoff, D.J., Mueller, S., Chao, L., Truran Sacrey, D., Laxer, K., Weiner, M. W., 2006. N-Acetylaspartate as a marker of neuronal injury in neurodegenerative disease. Adv. Exp. Med. Biol. 576, 241–363. https://doi.org/10.1007/0-387-30172-0_17.

Semenza, C., Meneghello, F., Arcara, G., Burgio, F., Gnoato, F., Facchini, S., Benavides-Varela, S., Clementi, M., Butterworth, B., 2014. A new clinical tool for assessing numerical abilities in neurological diseases: Numerical activities of daily living. Front. Aging Neurosci. 6, 1–8. https://doi.org/10.3389/fnagi.2014.00112.

Sheppard, D.P., Pirogovsky-Turk, E., Woods, S.P., Holden, H.M., Nicoll, D.R., Filoteo, J. V., Corey-Bloom, J., Gilbert, P.E., 2017. Everyday Functioning in Huntington's Disease: A Laboratory-Based Study of Financial Management Capacity. Appl. Neuropsychol. 24, 176–182. https://doi.org/10.1080/23279095.2015.1125904.

Sherod, M.G., Griffith, H.R., Copeland, J., Belue, K., Krzywanski, S., Zamrini, E.Y., Harrell, L.E., Clark, D.G., Brockington, J.C., Powers, R.E., Marson, D.C., 2009. Neurocognitive predictors of financial capacity across the dementia spectrum: Normal aging, mild cognitive impairment, and Alzheimer's disease. J. Int. Neuropsychol. Soc. 15, 258–267. https://doi.org/10.1017/S1355617709090365.

Stoeckel, L.E., Stewart, C.C., Griffith, H.R., Triebel, K., Okonkwo, O.C., den Hollander, J. A., Martin, R.C., Belue, K., Copeland, J.N., Harrell, L.E., Brockington, J.C., Clark, D. G., Marson, D.C., 2013. MRI volume of the medial frontal cortex predicts financial capacity in patients with mild Alzheimer's disease. Brain Imaging Behav. 7, 282–292. https://doi.org/10.1007/s11682-013-9226-3.

Stys, P.K., Zamponi, G.W., van Minnen, J., Geurts, J.J.G., 2012. Will the real multiple sclerosis please stand up? Nat. Rev. Neurosci. 13 (7), 507–514. https://doi.org/10.1038/nrn3275.

Tolbert, S., Liu, Y., Hellegers, C., Petrella, J.R., Weiner, M.W., Wong, T.Z., Murali Doraiswamy, P., 2019. Financial Management Skills in Aging, MCI and Dementia: Cross Sectional Relationship to 18F-Florbetapir PET Cortical β-amyloid Deposition. J. Prev. Alzheimer's Dis. 6, 274–282. https://doi.org/10.14283/jpad.2019.26.

Toplak, M.E., West, R.F., Stanovich, K.E., 2013. Practitioner Review: Do performance-based measures and ratings of executive function assess the same construct? J. Child Psychol. Psychiatry Allied Discip. 54, 131–143. https://doi.org/10.1111/jcpp.12001.

Tracy, V.L., Basso, M.R., Marson, D.C., Combs, D.R., Whiteside, D.M., 2017. Capacity for financial decision making in multiple sclerosis. J. Clin. Exp. Neuropsychol. 39, 46–57. https://doi.org/10.1080/13803395.2016.1201050.

Triebel, K.L., Martin, R., Griffith, H.R., Marceaux, J., Okonkwo, O.C., Harrell, L., Clark, D., Brockington, J., Bartolucci, A., Marson, D.C., 2009. Declining financial capacity in mild cognitive impairment: A 1-year longitudinal study. Neurology 73, 928–934. https://doi.org/10.1212/WNL.0b013e3181b87971.

Van Der Elst, W., Van Boxtel, M., Van Breukelen, G., Jolles, J., 2006a. The Letter Digit Substitution Test: Normative data for 1,858 healthy participants aged 24-81 from the Maastricht Aging Study (MAAS): Influence of age, education, and sex. J. Clin. Exp. Neuropsychol. 28, 998–1009. https://doi.org/10.1080/13803390591004428.

Van Der Elst, W., Van Boxtel, M.P.J., Van Breukelen, G.J.P., Jolles, J., 2006b. The concept shifting test: Adult normative data. Psychol. Assess. 18, 424–432. https://doi.org/10.1037/1040-3590.18.4.424.

Van Der Elst, W., Van Boxtel, M.P.J., Van Breukelen, G.J.P., Jolles, J., 2006c. The stroop color-word test: Influence of age, sex, and education; and normative data for a large sample across the adult age range. Assessment 13, 62–79. https://doi.org/10.1177/1073191105283427.

Van Hooren, S.A.H., Valentijn, A.M., Bosma, H., Ponds, R.W.H.M., Van Boxtel, M.P.J., Jolles, J., 2007. Cognitive functioning in healthy older adults aged 64-81: A cohort study into the effects of age, sex, and education. Aging, Neuropsychol. Cogn. 14, 40–54. https://doi.org/10.1080/138255890969483.

Wadley, V.G., Harrell, L.E., Marson, D.C., 2003. Self- and informant report of financial abilities in patients with Alzheimer's disease: reliable and valid? J. Am. Geriatr. Soc. 51, 1621–1626. https://doi.org/10.1046/j.1532-5415.2003.51514.x.

White, T., Stern, R.A., 2003. Neuropsychological Assessment Battery: Psychometric and tehcnical manual. Psychological Assessment Resources, Lutz, FL.

Wicklund, A.H., Johnson, N., Rademaker, A., Weitner, B.B., Weintraub, S., 2007. Profiles of decline in activities of daily living in non-Alzheimer dementia. Alzheimer Dis. Assoc. Disord. 21, 8–13. https://doi.org/10.1097/WAD.0b013e3180324549.

Wijnands, J.M.A., Kingwell, E., Zhu, F., Zhao, U., Högg, T., Stadnyk, K., Ekuma, O., Lu, X., Evans, C., Fisk, J.D., Marrie, R.A., Tremlett, H., 2017. Health-care use before a first demyelinating event suggestive of a multiple sclerosis prodrome: a matched cohort study. Lancet Neurol. 16 (6), 445–451. https://doi.org/10.1016/.S14744422(17)30076-5.